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A Quality Improvement of Manufacturing Process for Jasmine Rice 105 by Applying the Design of Experiment.

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The objective of this research is to determine the optimum factors for rice production in the jasmine rice 105 cultivating process, which is beneficial to rice farmers in Chachoengsao and other provinces with the same soil series. By using Generals Full Factorial Design of Experiment with controlled factors, the expected variables were soil (Chachoengsao and Don Rai soil series), Fertilizer (compost, manure, bio-compost, chemical fertilizer, compost with chemical fertilizer, manure with chemical fertilizer and bio-compost with chemical fertilizer) and planting period (season and off season). The experiments were repeated to carry out under the same conditions of 3 replications. The response was the production of jasmine rice 105. The analysis showed that the soil, fertilizer and planting period gave P-Value equal to 0.000 that is less than the significance level ($\alpha = 0.05$). It means all 3 factors influenced the quantity of rice production. For the test of appropriateness of the main factors and contributing factors in rice production, it was found that the optimum factor to achieve the highest average production was cropping in the seasons with manure and Don Rai soil series factors.

Keywords: Design of Experiment, Jasmine rice 105, Fertilizers, Soil, Planting season

Introduction

It is generally accepted from domestic and international consumer that Thailand is a high-quality source of Khao Hom Mali production. However, jasmine rice exports have a tendency become lower. Of course, the problem is that the price current of Thai Jasmine rice is higher than the actual price in the marketplace. In addition, rise prices make Thai farmers accelerate a large quantities of rice production, regardless of quality. For example, accelerated harvesting before period have an effect on the high moisture paddy in rice that affected the quality of rice whole kernels and increased percentage of rice broken kernels. In addition, non-standard planting also affects the quality of grain size and softness. Therefore, it is concerned about the future of rice

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exports, especially in Thai jasmine rice sector. Rice product per rai of Thailand is less than neighboring countries with similar rice and soil quality. Both quality and quantity problems of jasmine rice is lower than the standard that Thai farmers should not using a traditional way of rice production. They think how the industry will produce more productivity. The researcher collected rice kernels of Jasmine Rice 105 (KDML 105) from 25 farmers in Chachoengsao province to measure the weight of rice kernels. The result found that the average weight was 2.54 grams per 100 seeds, which was lower than the standard (2.77 grams per 100 seeds). In addition, the researcher collected KDML 105 rice was produced from other sources in four provinces: Surin, Suphan Buri, Chiang Rai, and Chachoengsao to investigate the quality of rice by cooked to give 30 samples of volunteers try to eat. In conclusion, rice product from Chachoengsao province was satisfactory in terms of seed maturity, slender length, whiteness, completeness, toughness and sticking, rubberizes, aroma of rice, softness of rice, sweetness, and the overall quality of Jasmine Rice 105 was 3.77, followed by other provinces of 3.68, 3.63 and 3.55 respectively. Based on the rice kernels quality data and KDML 105 rice, it shown that although the quality of rice kernels and weight is lower than the standard, the cooked rice high quality is dependent on the consumer. The researchers were interested in finding path to improve the quality of the production process and increase the production of KDML 105 rice. The design of experiments was designed to examine in series of soil both Chachoengsao and Don Rai Series in Chachoengsao province.

Objectives: objective of this research is to determine the optimum factors for rice production in the jasmine rice 105 cultivating process

Materials and methods

Instrument and Tools

The study was to determine the factors appropriate to the quantity of rice production in the KDML 105 rice cultivation. It consists of seeds, soil, fertilizer, water levels and digital scales. There are instrument and tools as follows:

Seed of Khao Dawk Mali 105 Rice

The researcher selected rice seeds that meet quality standards from the Department of Rice, Ministry of Agriculture and Cooperatives of Thailand. It had germination rate of seeds higher than 80 percent. The seed were verified for weight, length, width and thickness with a weighing meter. And it was checked

again with a magnitude meter before planting to comparison with the KDML 105 standard values of the Department of Rice. In this study, we used 100 seeds with grain weight about 2.77 grams, the grain length 10.50 mm, width 2.50 mm and thickness was 1.90 mm (Department of Rice, 2013). In this experiment, firstly, we taken seeds soak in water for 2 days. Next, the seed ware used to sowed dare for 15 days. Lastly, a black pots was used to transplanting rice for 5 rice seedlings.

The Soil or Series of Soil

The soil or series of soil for rice cultivation in each area will have the physical characteristics of different soil series, which vary widely in the area. Result of other research found that the average rice products per rai of Thailand was low level. When the farmer want to increase productivity, more inorganic substances are used. It is a cause of soil degradation problem in term of physics, chemistry and biology (Agr *et al*., 2012). In case of rice cultivation, it has to analyze physical and chemical properties of the soil (Hashem, 2013), (Vijay *et al*., 2013). Soil preparation for the experimental design of KDML 105 was conducted using Soil Series 3 (Chachoengsao Soil Series) and Soil Series 35 (Don Rai Soil Series). We examined the quality of the soil used for planting by soil sampling. (Department of Land Development, 2014). The soil sampling was sent to analyze at Office of Land Development Chachoengsao Province to determine the acidity and alkalinity (pH), organic matter and NPK (Nitrogen (N), Phosphorus (P), Potassium (K)). It was found that Don Rai Soil Series had pH of 6.0 (medium acid), which did not require soil treatment. The Chachoengsao Soil Series had a pH of 4.3 (severe acid), which required 110 grams of soil treatment per pot. In addition, it was found that the measured NPK levels of both soil series were moderate N, high P, and very high K value.

Black Pot

In this experiment, the 15 inch plastic of black pot with total of 42 pots was used to put both Chachoengsao Soil Series 21 pots and Don Rai Soil Series 21 pots.

Fertilizer

Fertilizer or plant nutrients are important factors in rice production. If it has a good fertilizer management, it will reduce the cost of rice production and also increase productivity (Chourwong, 2013), (Chourwong, 2014). Soil quality should be analyzed for appropriate fertilizer application according to result of soil analysis. (Lima *et al*., 2010), (Lima *et al*., 2011). In this study, we divided

the method of fertilizing for application in experimental rice plot into seven levels as follows:

1) In first level, the researcher used the compost application at the rate calculated from result of soil analysis and nutrient values in the fertilizer by composting before planting 7-14 days at the rate of 37.24 grams per pot.

2) In second level, we used the manure fertilizers application before planting 7-14 days at the rate of 22.66 grams per pot.

3) In third level, the result of pouring the enzyme ionic plasma into the soil in a pot before planting at 0.35 ml per pot of three times. We divided into three times as follows: 1) put enzyme ionic plasma after planting black rice seedlings at the age of rice seven days, 2) put the enzyme ionic plasma water away from the first 14 days, and 3) enzyme ionic plasma was used to spraying time seven days a time at the rate of 100 ml per 20 liters of clean water.

4) In fourth level, chemical fertilizer was divided into two periods. In the first period, after one week of rice planting, chemical fertilizer formula 16-20-0 was applied at the rate of 0.70 grams per pot and chemical fertilizer formula 46-0-0 was applied at 0.070 grams per pot. And the second period, chemical fertilizer formula 46-0-0 was applied at a rate of 0.28 grams per pot.

5) In fifth level, chemical fertilizer mixed with compost fertilizers was divided into two periods. In the first period, chemical fertilizer formula 16-20-0 was used at 0.35 grams per pot and compost was used at 18.70 grams per pot. And the second period, chemical fertilizer formula 40-0-0 at 0.14 grams per pot was used at the beginning of rice create inflorescence.

6) In sixth level, chemical fertilizers mixed with manure fertilizers was divided into two periods. In the first period, chemical fertilizer formula 16-20-0 was used at 0.35 grams per pot and compost was used at 11.33 grams per pot. And the second period, chemical fertilizer formula 40-0-0 at 0.14 grams per pot was used at the beginning of rice create inflorescence.

7) In seventh level, the results of chemical fertilizers mixed with enzyme ionic plasma were divided into two phases. In the first phase, chemical fertilizer formula 16-20-0 at 0.70 grams per pot was used to spraying time fourteen days a time at the rate of 100 ml per 20 liters of clean water. And the second phase, chemical fertilizer formula 40-0-0 at 0.14 grams per pot was used at the beginning of rice create inflorescence.

Water Level

Use of water levels in rice fields in Thailand depend on water and irrigation systems. If the water is insufficient, it should be at least 5-10 cm, especially during the initial stage of rice planting (Pailin *et al*., 2008), (Boon *et al*., 2556). This study suggested that rice product with non-flooded water

management method was not different from flooded water management method throughout the growing rice season. This research was conducted to control the water level in plastic pots used in rice at the KDML 105 rice production at the five centimeter level of each experimental sets.

Digital weighing scales

Digital weighing scales were used for rice kernel weigh and measure quality of rice seed for standards before pre-planting and post-harvest, and weighing the fertilizer for used in experiment process of rice cultivation.

Experimental Methods

In this study, data collection and survey of environment in the study area was collected through using in-depth interview from rice farmers. It was found that Khao Dawk Mali 105 rice has susceptible to the disease. That is main cause that the farmers need to use insecticides and treatment of the disease. It also resulted in high production costs and production volumes did not meet the needs of farmers. Therefore, it is necessary to find suitable factors in the cultivation of KDML 105 rice. Design of experiment was used to analyze data from brainstorming by experts and farmers. Result of analysis was found that the main factors that comprise: 1) control factors such as: rice seed, type of soil, type of fertilizer, water level and 2) uncontrolled factors such as: rainfall, relative humidity, temperature and sunlight. In this research, the researchers used experimental design to determine the suitable factors for rice production of KDML 105 rice cultivating process using Generals Full Factorial Design (Montgomery *et al*., 2005). An analysis of data mixed with three contributing factors were: 1) the soil series, and 2) type of fertilizer, and 3) the growing rice season.

Result

Results of Sample Size

Minitab program was used to find the sample size determination for KDML 105 paddy for rice yield test. Result of data analysis at significant level of 0.05 was done by collecting paddy data from rice farmers. Standard deviation of production value was used to find the size of the samples, the Minitab program is based on Sensitivity Analysis from the Power of Test; 1-β that is higher than 0.8. (Cholsin Somboon 2010) as shown in Figure 1. The

sample size of three samples was 0.863 Power of Test, 1 - β > 0.8. Thus, the sample size test in this experiment was 3.

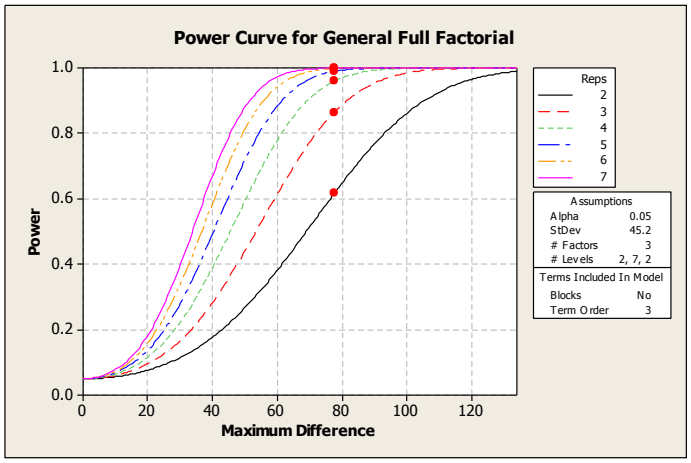


Figure 1. The sample size

Results of the Experimental Design of Factorial Experiments

2.1 Preliminary Experiments Preliminary experiments were used to study expected factors for quantity of KDML 105 rice production using statistical analysis of experimental results and using principle of experimental design analysis by randomization. The researcher used experimental design to control factors in the KDML 105 rice cultivation. The variables of control factors were: 1) two series of soil: Chachoengsao Series and Don Rai Series, 2) two growing rice season: in-season and off-season rice, and 3) seven types of fertilizer: compost, manure, enzyme ionic plasma, chemical fertilizer, compost mixed with chemical fertilizer, manure mixed with chemical fertilizer, and enzyme ionic plasma mixed with chemical fertilizers. This process was repeated three times under controlled conditions. There were responding variables of rice production per pot. The experiment was conducted in 28 conditions and totaling 84. Experiment data shown in Table 1 and analyzed the results with Minitab program.

Table 1 Full-scale factorial effect of paddy yield on pots (Grams per pot)

fertilizer	no.1						no. 2					
	Chachoengsao soil Replicate			Don Rai soil Replicate			Chachoengsao soil Replicate			Don Rai soil Replicate		
	1	2	3	1	2	3	1	2	3	1	2	3
Compost	29.82	30.54	28.27	48.36	46.69	44.86	31.06	17.28	25.12	51.12	41.45	30.79
manure	42.38	40.86	45.46	63.68	62.94	57.78	38.41	28.65	45.60	69.21	65.28	60.98
bio-fermented water	28.55	31.74	32.98	39.65	45.32	44.48	22.70	17.96	37.30	37.00	46.46	24.33
Chemical fertilizer	25.49	57.23	39.84	48.42	46.36	47.94	23.62	26.65	28.76	38.39	42.53	44.83
Compost + Chemical fertilizer	37.28	39.41	40.52	52.62	45.58	46.39	25.59	30.67	41.04	49.66	35.80	44.07
manure + Chemical fertilizer	51.28	47.56	45.85	59.36	60.83	58.25	50.29	37.65	41.95	45.61	31.63	36.90
bio-fermented water + Chemical fertilizer	39.64	36.54	46.60	47.62	46.46	42.87	32.72	28.86	26.60	48.28	46.46	32.33

2.2 Model / Adequacy Checking Conclusions derived from variance analysis and the adequacy of the trial will be checked (Montgomery, 2005). Validation of the experimental form of rice production checking the suitability and the accuracy of the data obtained from the trial. The results can be shown in Figure 2, assuming that the residuals obtained from the experimental data must be in accordance with the principle that the residuals are normally distributed. It is independent of the mean of close to 0 and has a stability, so the data from the trial is accurate and reliable. In case of checking the normal distribution of residuals, checking the residuals, checking the variance and actability, and independence verification of the residuals. The results of the feasibility examination according to the hypothesis are shown as follows.

2.3 Independent Verification of the Residuals Independent verification of the residuals of the volume of production from order graph. Consideration of the data from the experiment to create a distribution chart in the order of experiment. When considering the distribution of data on the chart. Distribution

of residuals is independent of each other because it cannot estimate the exact format.

2.4 Normal Distribution The residuals of the quantity produced from the Normal Probability Plot are the residuals / distributions used in the normal distribution test. Production volume data It was found that the normal distribution. Because residuals are distributed along straight lines and straight lines, nothing shows up. This means that the information is sufficient.

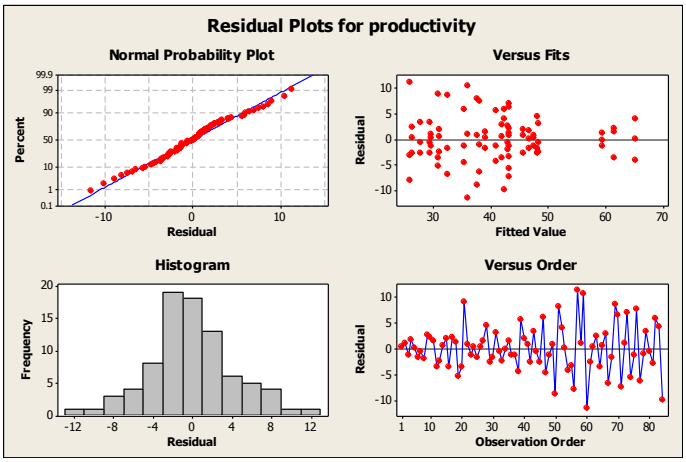


Figure 2 Verification of the quality of the data of a factorial experiment.

2.5 Variance Stability of the Versus Fits graph is the Residuals / Residuals / Value / Residuals chart. Stable data of variance Since the values are similar in each location and pattern, the residuals

Analysis of variance / (ANOVA) / of paddy production

Based on the results of validation of the experimental model, it was found that No experimental abnormalities occur and the data is reliable. The data of the volume of production. To analyze the variance / (ANOVA) / to study the influence of all factors. The significance level $\alpha = 0.05$ is shown in Table 2.

Based on the analysis of variance / (ANOVA) of paddy production Using the program Minitab / 16 / Free / Trial / For Analysis / Main / Effect / And. Interaction When analyzing the variance, R2 was 83.75%. The soil series gave P-Value / = / 0.000. It is less than the significance level of α = / 0.05, which means that the soil factor determines the volume of production. The P-Value = 0.000 was significantly lower than the significance level of α = / 0.05. The P-

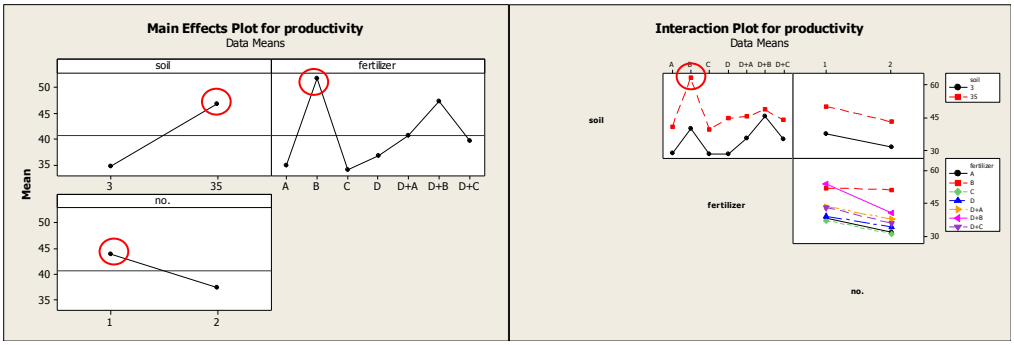
Value = 0.000 was significantly lower than the significance level α = 0.05. The combination of soil and fertilizer type gave P-Value = 0.002 less than the significance level of α = / 0.05. (Interaction). The soil series together with the planting period gave P-Value = 0.535 greater than the significance level α = / 0.05, ie, soil factor with non-interaction period. (Interaction). Fertilizer coupled with planting time gave P-Value = 0.238 greater than significance level of α = / 0.05, ie, factor of fertilizer type with no interval of cultivation. (Interaction). The soil series, coupled with the type of fertilizer and the time of planting, gave P-Value = 0.060 significantly higher than the significance level α = 0.05. Interactions Interaction

Table 2 Show the results of full-scale experimental data analysis of crop yields.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F	P
Soil	1	3050.34	3050.34	104.83	0.000
fertilizer	6	3139.03	523.17	17.98	0.000
No.	1	866.38	866.38	29.77	0.000
Soil + fertilizer	6	710.06	118.34	4.07	0.002
Soil*No	1	11.34	11.34	0.39	0.535
fertilizer *No	6	241.20	40.20	1.38	0.238
Soil*fertilizer *No	6	377.59	62.93	2.16	0.060
Error	56	1629.53	29.10		
Total	83	10025.47			
R-Sq = 83.75%	R-Sq(adj) = 75.91%				

Result of the Study of Suitability of Keys Factors and Contributing Factors to Rice Production.

Due to the influence of the contributing factors between series of soil and type of fertilizer, the influence on the average production volume was significantly taken into account in the interpretation of the main influence. In Fig. 3a show evident that the rice yields are the highest in average compared to the Chachoengsao soil series in all types of fertilizer. In Fig. 3b show the rice yields are the highest in average compared to the Chachoengsao soil series. The type of fertilizer is that the manure produces the highest average production and during the growing season, it is seen that in the growing seasons, the average production volume is highest. Therefore, the optimum factor to achieve the highest average production indicated that the optimum factors to achieve the highest average were: 1) in-season plant rice, 2) Don Rai soil series, and 3) manure fertilizers.



a. Testing the suitability of the main factors. b. Factor suitability testing

Fig. 3 Test of appropriateness of factors of rice production.

Discussion

The objective of this research was to determine the factors appropriate to the quantity of rice production in the KDML 105 rice cultivating process using Generals Full Factorial Design. The researcher used experimental design to control factors in the KDML 105 rice cultivation. The variables of control factors were: 1) two series of soil: Chachoengsao Series and Don Rai Series, 2) two growing rice season: in-season and off-season rice, and 3) seven types of fertilizer: compost, manure, enzyme ionic plasma, chemical fertilizer, compost mixed with chemical fertilizer, manure mixed with chemical fertilizer, and enzyme ionic plasma mixed with chemical fertilizers. Preliminary experiments were used to study expected factors for quantity of KDML 105 rice production using statistical analysis of experimental results and using principle of experimental design analysis by randomization. The experimental result of appropriateness of the key factors and contributing factors to KDML105 rice production indicated that the optimum factors to achieve the highest average were: 1) in-season plant rice, 2) Don Rai soil series, and 3) manure fertilizers. Rojana *et al.*, (2012) study on appropriate fertilizer application for sustainable rice cultivation. The report shown that soils with high fertility levels only organic fertilizer should be used at the rate of 150 kg per rai. Organic fertilizers mixed with chemical fertilizers should be used in the ratio of 1: ¼. Organic fertilizer is 150 kg per rai with chemical fertilizer formula 16-16-8 at the rate of 6.25 kg per rai. Organic fertilizers mixed with chemical fertilizers should be used in proportion 2: ¼, organic fertilizer at the rate of 300 kg per rai with chemical fertilizer formula 16-16-8 at the rate of 6.25 kg per rai. Sudhir-Yadav, *et al*. (2011) study effect of water management on dry rice seed and the transfer

of seedlings to the field plots. The report shown that groundwater loss was of concern. The study found that the possibility of reducing the amount of irrigation while still yielding a PTR change with DSR and AWD provide soil viscosity to retain water below 20 kPa at 20 cm depth. Lima *et al* (2011) conducted soil quality assessment in rice production system. Semi-structured interviews shown that there were three things that was useful for a farmer's decision. Is the growth of naturally occurring vegetable crops. Rice root growth and soil coloring potential of using local wisdom for soil quality maintenance and sustainable soil development. Sommai *et al*., (2010) study on chemical fertilizer application based on soil analysis in saline soils in Nakhon Ratchasima province to reduce the cost of rice production from chemical fertilizer application. Four replicate RCB experiments were planned. Seven methods of rice cultivating KDML 105 rice were applied. Rice Department's recommendation was the highest rice yield, followed by chemical fertilizer application based on soil analysis. Soil management program and fertilizer conversion for the rice yield did not differ statistically.

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References

Boon Hong J, *et al*. (2013). Crop yield and yield components of white rice Jasmine 105 mutants when using different numbers of seedlings per clump. Journal of Science and Technology Year 21 Issue 6 (Special edition).

Department of Rice. (2012). News on the establishment of the Department of Rice, 5th Anniversary, Chatuchak, Bangkok.

Department of Rice. (2016). Jasmine Rice 105. Chatuchak Bangkok.

Department of Land Development. (2015). Characteristics and properties of central soil series. Bureau of Soil Science and Soil Research Agriculture Cooperatives. Retrieved on April 15, 2015, from http://oss101.ldd.go.th/web_thaisoils / pf_desc / central / Dm.htm

Hashem A. (2013). Grain Yield and Nutrition Uptake of Rice (*Oryza sativa* L.) Cultivars in Competition with Barnyardgrass (*Echinochloa crus-gali* (L.) *P. Beauv*.). Philipp Agric Scientist 95 (1):112-118

Lima, A.C.R., *et al*. (2011). Farmers' assessment of soil quality in rice production systems. NJAS –Wageningen Journal of Life Sciences 58: 31–38.

Montgomery, D.C. (2005). Design and Analysis of Experiment. The United States of America: John Wiley & Sons.

Prawach C. (2013). Reducing Production Costs of Jasmine Rice with Quality Control Circle. The Fourth Asian Conference on the Social Sciences 2013, the Rihga Royal hotel, Osaka, Japan.

Prawach C. (2014). Quality Control Circle: A Case Study to Reduce Production Costs of Jasmine Rice in Trantip group Chachoengsao province, Thailand. The Fourth Asian Conference on the Social Sciences 2014, Ramada Osaka, Japan.

Pirin N, *et al* (2008).The SRI in Chachoengsao Province The Rice and Grains Conference 2007, Volume 1/2, Bangkok.

Rujana T, *et al*. (2012). Proper use of fertilizers for sustainable rice cultivation. Academic conference 2nd National Rice, 21-23 Dec 2012, Bangkok.

Sommitlina *et al*. (2010). Chemical fertilizer application based on soil analysis in saline soils. Nakhon Ratchasima. Document the Conference on Rice and Cereal Winter Northeastern Rice Research Center 2009 March 24-25, 2010 at Major Grand Hotel, Chum Phae District, Khon Kaen Province.

SaiCholsin S. (2012). Engineering Statistics, 4th edition, Chamchuri Product: Bangkok.

Sudhir-Yadav, *et al*. (2011). Effect of water management on dry seeded and puddled transplanted rice. Part 1: Crop performance. Field Crops Research 120, 112–122

Vijay Singh M., Maurya, B.R., Verma, R. and Meena, S.K. (2013). Effect of Concentrate Manure and Inorganic Fertilizers on Soil Electro - Chemical Properties and Productivity of Rice (Oryza sativa L.) under Interceotisol of Varanasi. Annals of Biology 29 (3): 358-363.

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