ໂອກາດ ແລະ ຄວາມເປັນໄປໄດ້ ໃນການພັດທະນາເຂົ້າໜຽວ ລູກປະສົມ ຢູ່ ສປປ ລາວ

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ບົດຄັດຫຍໍ້

ດັ່ງທີ່ຮູ້ນຳກັນແລ້ວວ່າ ລັກສະນະດີເລີດ ທີ່ຖ່າຍຖອດ ຈາກ ພໍ່ ຫຼື ແມ່ (heterosis) ຂອງແນວພັນລູກປະສົມ ແມ່ນປັດໄຈຫຼັກ ໃນການຍົກສະມັດຕະພາບ ຂອງບັນດາພືດລູກນັບທັງເຂົ້າ. ຈຸດປະສົງ ຂອງ ການຄົ້ນຄວ້າທົດລອງນີ້ ແມ່ນເພື່ອ: (1) ສຶກສາເບິ່ງ ຮີເຕີໂຣສີດສ ຂອງສາຍພັນເຂົ້າໜຽວລູກປະສົມ ແລະ ເຂົ້າຈ້າວລູກປະສົມ ໂດຍນຳໃຊ້ແນວພັນເຂົ້າຂອງລາວ ເປັນພໍ່ພັນ; (2) ສຶກສາເບິ່ງຄຸນນະພາບທາງດ້ານເຄມີ ແລະ ຄຸນນະພາບການກິນ ຂອງເຂົ້າລູກປະສົມ.

ຜົນຂອງການສຶກສາພົບວ່າ ເຂົ້າລູກປະສົມ ທີ່ໄດ້ມາຈາກແມ່ພັນ IR75589-31-27-8-33S ໃຫ້ຜົນຜະລິດສະເລ່ຍ (4864 ± 303 kg/ha) ຫຼາຍກວ່າ ເຂົ້າລູກປະສົມທີ່ໄດ້ຈາກ IR58025B (4600 ± 377 kg/ha) ແລະ IR65 (3483 ± 627 kg/ha). ລະຫວ່າງພໍ່ພັນນັ້ນ ພົບວ່າ ເຂົ້າລູກປະສົມ ທີ່ໄດ້ຈາກ TDK1, TDK3 ແລະ LNT1 ໃຫ້ຜົນຜະລິດສູງສະເລ່ຍ 4813 ± 740 kg/ha, 4717 ± 255 kg/ha ແລະ 4633 ± 433 kg/ha ຕາມລຳດັບ. ເຂົ້າລູກປະສົມ (IR75589-31-27-8-33S/TDK6) ໃຫ້ຜົນຜະລິດສູງສຸດ (5397 kg/ha) ແລະ ເຂົ້າລູກປະສົມ (IR65/TDK9) ໃຫ້ຜົນຜະລິດຕ່ຳສຸດ (2146 kg/ha).

ຄວາມແຕກຕ່າງ ທາງດ້ານຫຼັກສະນະດີເລີດ ທີ່ຖ່າຍຖອດ ຈາກພໍ່ແມ່ ຂອງເຂົ້າລູກປະສົມ ໃນລະບົບທີ່ນຳໃຊ້ ສາມສາຍພັນໃນການຜະລິດເຂົ້າລູກປະສົມ ແມ່ນສັງເກດໄດ້ ແຕ່ -23% ຫາ +25% ແລະ ແຕ່ -1% ຫາ +99% ສຳລັບລະບົບ ທີ່ນຳໃຊ້ ສອງສາຍພັນ. ເປີເຊັນເຂົ້າສານເມັດເຕັມສີໄດ້ ສັງເກດເຫັນ ແຕ່ 43% ຫາ 67%. ເປີເຊັນອາມີໂລ (amylose) ທີ່ພົບຢູ່ໃນເຂົ້າຈ້າວລູກປະສົມ ແມ່ນ 7% ຫາ 31% ແລະ ພົບຢູ່ໃນເຂົ້າໜຽວ ແມ່ນ 0% ຫາ 2%. ເຂົ້າລູກປະສົມທັງໝົດ ແມ່ນຈັດຢູ່ໃນປະເພດ ອ່ອນ, ຄ່າຄວາມໜຽວຂອງວຸ້ນ (gel consistancy) ປ່ຽນແປງແຕ່ 61 ມມ ຫາ 100 ມມ. ອຸນຫະພູມໃນ ການຫຼາຕົ້ມ (gelatinization temperature) ຂອງເຂົ້າລູກປະສົມ ສັງເກດໄດ້ແຕ່ 62°C ຫາ 72°C. ຄຸນນະພາບ ການກິນຂອງເຂົ້າໜຽວລູກປະສົມ ເຫັນວ່າ ບໍ່ມີຄວາມສຳພັນກັບເປີເຊັນ ອາມີໂລ ທີ່ມີຢູ່ນຳເມັດເຂົ້າສານ ໃນຂະນະທີ່ ຄຸນນະພາບການກິນຂອງເຂົ້າຈ້າວ ແມ່ນມີຄວາມສຳພັນກັບຈຳນວນເປີເຊັນ ອາມີໂລ ທີ່ມີຢູ່ນຳເມັດເຂົ້າສານ.

ການພັດທະນາ ເຂົ້າໜຽວລູກປະສົມ ສຳລັບ ສປປ ລາວ ທີ່ນຳໃຊ້ ລະບົບ 2 ສາຍພັນ (TGMS) ນັ້ນ, ຢີນ (gene) ທີ່ຕ້ອງການ ຈາກ IR75589-31-27-8-33S ແລະ ສາຍພັນອື່ນໆ ທີ່ຢູ່ພາຍໃຕ້ລະບົບ ດັ່ງກ່າວ ຈະຕ້ອງໄດ້ຖ່າຍໂອນ ເຂົ້າສູ່ເຂົ້າໜຽວຂອງລາວ. ສຳລັບລະບົບທີ່ນຳໃຊ້ ສາມສາຍພັນ (CMS) ນັ້ນ, ຈະຕ້ອງໄດ້ຊອກຫາສາຍພັນ ທີ່ຈະນຳໃຊ້ເປັນໂຕຮັກສາແມ່ພັນ (maintainer lines) ແລະ ສາຍ ພັນທີ່ຈະນຳໃຊ້ເປັນພໍ່ພັນ (restorer lines) ສາກ່ອນ ຈາກທະນາຄານເຊື້ອພັນເຂົ້າລາວ ກ່ອນທີ່ຈະຖ່າຍ ໂອນຢີນ (gene) ທີ່ຕ້ອງການ ຈາກ IR58025A ແລະ ສາຍພັນອື່ນໆ ຈາກລະບົບດັ່ງກ່າວ ເຂົ້າສູ່ເຂົ້າ ໜຽວ ຂອງ ລາວ.

Key words: *heterosis, waxy hybrid rice, grain quality, grain yield, two-line system, three-line system.*

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OPPORTUNITY AND CHALLENGES IN RESEARCH AND DEVELOPMENT OF WAXY HYBRID RICE IN LAO PDR

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Abstract

Heterosis is known to be a major factor for increased production in several crops, including rice. The objectives of this research are: (1) to study heterosis of waxy and non waxy hybrid rice based on Lao HYVs and (2) to evaluate grain quality (chemical and eating quality) of waxy and non waxy hybrid rice.

Results show the performance of the hybrids in terms of grain yield varies depending on the female parent used. Hybrids derived from IR75589-31-27-8-33S showed higher main grain yield (4864 ± 303 kg/ha) compared to IR58025B (4600 ± 377 kg/ha) and IR65 (3483 ± 627 kg/ha). Among the male parents, TDK1 had the highest yield (4813 ± 740 kg/ha), followed by TDK3 (4717±255 kg/ha) and LNT1 (4633 ± 433 kg/ha). Hybrid (IR75589-31-27-8-33S/TDK6) has the highest grain yield with (5397 kg/ha) while the lowest yield was observed in hybrid (IR65/TDK9) with 2146 kg/ha.

Positive and negative level of heterobeltiosis for three-line hybrid rice system ranged fro -23% to 25% and heterosis over male parent for two-line hybrid rice system ranged from -1% to 99%. Head rice recovery of the hybrids ranged from 43% to 67%. Amylose content of non-waxy hybrids ranged from 7% to 31%, while the waxy hybrids ranged from 0% to 2%. All of the hybrids have soft gel consistency ranged from 61 cm to 100 cm. Gelatinization temperature of both waxy and non-waxy hybrids ranged from 62°C to 75°C. Eating quality of the waxy hybrids was not associated to low amylose content, while those of the non-waxy hybrids was associated to low, medium and high amylose content.

To develop waxy hybrid rice for Lao PDR, using the two-line system, the thermo-sensitive genic male sterility system (TGMS) of IR75589-31-27-8-33S and other lines should be transferred to the back ground of waxy rice. For the three lines hybrid system, the waxy maintainer and restorer lines should be identified from the Lao germplasm, before the desirable gene from IR58025A or other lines under this system will be transferred in to the background of waxy rice.

Key words: *heterosis, waxy hybrid rice, grain quality, grain yield, two-line system, three-line system.*

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I. Introduction

The Lao people consume 171 kilograms per capita of milled rice per annum, which constitutes almost 70% of their calorie and protein intake (Maclean *et al.*, 2002). Achieving self-sufficiency in rice at the national level has been a top priority for the country since the introduction of the New Economic Mechanism (NEM) in 1986. Rice self-sufficiency was reported to have been achieved in 1999 at more than 2 million tons. The area planted to rice in 2005 was 793,980 hectares, representing more than 80% of the cropped land area with production of 2,568 million tons and an average yield of 3.49 t/ha (Lao-IRRI, 2005). The rice production systems in Laos can be classified into three broad ecosystems namely irrigated lowland, rainfed lowland, and rainfed upland. The rainfed lowland rice ecosystems can be divided into four main sub-ecosystems, namely favorable (10%), drought-prone (60%), drought and submergence-prone (20%) and submergence prone (10%) (Inthapanya *et al*., 1995; Linguist *et al*., 2006).

Lao PDR has the highest per capita production and consumption of glutinous rice in the world. Lao people also have a particularly strong cultural affinity for glutinous rice (Schiller., *et al* 2006). In 2005, approximate 93% of the total rice areas in Laos were planted to glutinous rice (Lao-IRRI, 2005). The highest proportion of glutinous rice (about 91%) is grown in dry season of irrigated environment. This environment is almost exclusively useful for the improved glutinous varieties released by the Lao National Rice Research Program (NRRP) since 1993 (Schiller *et al*., 2006). The preference for glutinous rice by the Lao people was seen in collecting mission in 1995-2000 where over 85% of lowland varieties collected were glutinous (Appa Rao *et al*., 2002).

Hybrid rice technology exploits the biological phenomenon of hybrid vigor (heterosis) to increase the yield potential of rice varieties (IRRI, 2002). Heterosis for yield in rice hybrids has been attributed to their increased dry matter production caused by higher leaf area index, higher crop growth rate, and increased harvest index resulting from increased spikelet number and increased grain weight (Virmani and Kumar, 2004). Rice hybrids have also shown significant heterosis for earliness, the higher yield coupled with slightly shorter duration resulted in higher per day productivity than inbred high yielding varieties (HYVs).

Hybrid rice technology was successfully developed in China since 1964. Since then, it has been adopted in 50% of

the 30 million ha of rice area in the country and applied in about 20 countries worldwide (Ma and Yuan 2003). In China, rice hybrids outyielded the inbred rice more than 15%, and contributed 60% of its national paddy production. Yield data of hybrid rice at International Rice Research Institute (IRRI), India, the Philippines, Bangladesh, Indonesia, Vietnam, Myanmar, and Sri Lanka clearly provided evidence for yield advantage of rice hybrids over HYVs. Since 1979, IRRI has been exploring the prospects of exploiting heterosis in the tropics to increase rice yield potential with the increasing rice demand, decreasing land area and water resources for rice production.

There are two systems for producing hybrid rice: (1) cytoplasmic-genetic male sterility systems, the lines from this system are controlled by the interaction of cytoplasmic and nuclear genes. This is also known as three-line hybrid system, because of the involvement of three lines, namely CMS (A line), maintainer (B line) and restorer (R line) (Yuan, 1977), and (2) environment-sensitive male sterile (EGMS) system of which male sterility of the female parent is controlled by recessive nuclear gene (Maruyama *et al*., 1991) regulated by day length and/or temperature. This is called the two-line hybrid system, because it involves only two parental lines, the EGMS line and pollen parent line.

Currently, parental lines and heterotic rice hybrids developed at IRRI are routinely evaluated for grain quality characteristics such as milling percentage, head rice recovery, size, shape, chalkiness, amylose content, gelatinization temperature, gel consistency, and aroma of the grain and compared with check varieties (Virmani, 2004). Hybridity does not impair grain quality in terms of physical and chemical characteristics as long as both parents possess acceptable grain quality (Khush *et al*., 1988). Apparent amylose content (AC), gel consistency (GC), and gelatinization temperature (GT) are recognized as the most important determinants of rice eating and cooking qualities (Little *et al*., 1958; Juliana, 1971; Cagampang *et al*., 1973; Webb, 1980; McKenzie and Rutger, 1983; Tang *et al*., 1991; Unnerve et al., 1992; Tan *et al*., 1999).

Future rice demand and supply in Laos is expected to grow substantially as the population is expected to increase from 5.8 million in 2005 to 7.7 million in 2020. At the current rate of population growth, the projected paddy rice requirement to meet the rice consumption need of the population in 2020 is about 2.8 million tons. (Inthapanya *et al*., 2006). Assuming that the total rice

area does not increase, the productivity of rice will have to increase to 4 t/ha (current average rice yield was 3.5 t/h), at the national level by 2020 to maintain self-sufficiency.

The development of the rice sector is always a priority of the Lao government for economic growth and for food security. The adoption of hybrid rice technology in China and Asia had increased rice production and had sustained food security. Therefore, the introduction of hybrid rice technology, especially glutinous hybrid rice technology to Lao PDR may provide a good opportunity to increase glutinous rice production in the country. The objectives of this research are: (1) to study heterosis of waxy and non waxy hybrid rice based on Lao HYVs and (2) to evaluate grain quality (chemical quality) of waxy and non waxy hybrid rice.

II. Materials and Methods

Evaluation of grain yield and heterosis. Hybridization was done in the dry and wet seasons of 2007 at the IRRI. All field experiments and chemical quality traits evaluation were conducted in the farm and grain quality laboratory of IRRI, Los Baños ($14^0$11'N, $121^0$15'E), Laguna, Philippines. Three lines from IRRI (IR58025B, IR75589-31-27-8-33S, and IR65) were used as female parents and crossed to the 19 Lao HYVs. A total of 57 crosses were made with 400 F1 hybrid seeds/cross. The hybrids and their parents were laid out in a Randomized Complete Block Design (RCBD) with 3 replications. Each plot was 1x5 m ($5m^2$) with spacing 20 x 20 cm (125 plants/plot). A total of 78 entries (57 F1 hybrids + 19 male parents + 2 female parents IR58025B and IR65) were grown in the field. F1 hybrid seeds were sown in December 15, 2007 and transplanting was done in January 8, 2008 at one seedling per hill. The harvested area was 2.76 m^2 (69 plants). Fertilizer rate of 100:40:30 kg/ha (N-P-K) was applied. At ripening stage, grain yield and yield parameters were gathered from random 10 plants per plot. Grain yield (kg/ha) was measured after threshing, cleaning and drying to 14% moisture content. The harvested seeds from the hybrid plants were used for evaluation of grain quality.

Quantitative data (yield, yield components and some agronomic traits) gathered from the field was analyzed using IRRISTAT. The analysis of variance (ANOVA) in RCBD was used to determine treatment differences using the procedure described by Gomez and Gomez (1983). Comparison of treatment means were carried out using the Least Significant Difference Test (LSD) at 5% level of significance. Heterobeltiosis and heterosis over male parent were calculated using formula below:

$$\text{Heterosis over male parent } (\%) = \frac{\text{F1} - \text{Male parent}}{\text{Male parent}} \times 100$$

$$\text{Heterobeltiosis } (\%) = \frac{\text{F1} - \text{Better parent}}{\text{Better parent}} \times 100$$

Milling quality (MQ). A 125g of rough rice sample with moisture content of approximately 12% to 14% was used to determine milling recovery. Rough rice sample was dehulled by using a Satake laboratory sheller. Brown rice was recorded before milling in a McGill mill number 2 for one minute. The milled rice sample was collected in a jar and was allowed to cool before weighing; the weight of the total milled rice was recorded. Whole grains (head rice) were separated from the total rice with rice-sizing device and recorded. The percentage of milling recovery was calculated as follows:

$$\text{Head rice } (\%) = \frac{\text{Weight of Head rice}}{\text{Weight of rough rice}} \times 100$$

Amylose content (AC). The milled rice sample was ground in an Udy cyclone mill (sieve mesh size 60), and 100 mg of rice powder was put into a 100 ml volumetric flash. One ml of 95% ethanol and nine ml of 1M sodium hydroxide (NaOH) were added respectively. The contents were heated in a boiling water bath and then allowed to cool for two hours before making up to 100 ml with distilled water. Five ml of the starch solution was put in a 100 ml volumetric flash with a pipette. One ml of 1M acetic acid and 2 ml of iodine solution (0.2 g iodine and 2 g potassium iodine in 100 ml aqueous solution) were added and the volume was made up with distilled water. The contents were mixed using a vortex genie mixer and left to stand for 20 minutes. Absorbance of solution was measured at 620 mm with an AutoAnalyser (Autoanalyser 3 Bran+Luebbe). Amylose content was calculated by comparison with the absorbance of the standards, namely IR29, IR24, IR64 and IR8.

Gelatinization temperature (GT). GT was measured by Differential Scanning Calorimetry (DSC) (DSC Q100, TA Instruments). The samples were ground in an Udy cyclone mill (sieve mesh size 60), and 4 mg of powder was mixed with water (8 ml) in an aluminum hermetic pan, and then the pans were sealed before heated under pressure from 35˚C - 100˚C in increments of 10˚C/min in the DSC. The gelatinization temperature was determined from the peak of the endotherm.

Gel consistency (GC). The milled rice sample and check (hard, medium and soft gel rice varieties) were ground in the Udy cyclone mill (sieve mesh size 100), and 100 mg of rice powder was weighed in duplicate into the culture tubes (13 mm x 100 mm). Ethyl alcohol (0.2 ml of 95%) containing 0.025% thymol blue and 2 ml of 0.2M KOH

were added with a pipette, respectively. The contents were mixed using a vortex genie mixer before cooking in a vigorously boiling water bath for 8 minutes, and left to stand at room temperature for 5 minutes, and then the tubes were cooled in ice-water bath for 20 minutes. Then, the tubes were laid horizontally on the laboratory table lined with millimeter graphing paper. The length of gel was measured in millimeters (mm) from the bottom of the tube to the gel front.

Eating quality (EQ). EQ was done based on endosperm type. For glutinous hybrids, the milled grains and the checks were soaked in water for 3 hours, followed by steam cooking for 30 minutes in the woven bamboo basket (1 sample/basket). For non-glutinous rice, milled grains and checks were steam cooked for 30 minutes at the water-rice ratio of 1:1 (1 sample/beaker). All samples were cooked using the similar techniques and duration of cooking. Tactile senses were tested based on standard descriptor (soft; medium and hard). A sensory panel composed of 40 farmers and researchers were invited for sensory evaluation. The preference test was completed over a period of 2 days with one replication being completed in a day. Samples were numbered and presented to the panel. For assessing quality using non-visual perceptions, they were blind-folded so that they will not be biased by the visual appearance of the rice sample.

III. Rrsults and Discusion

Performance of Hybrids. The performance of the hybrids in terms of grain yield varies depending on the female parent used. In this study, hybrids with IR75589-31-27-8-33S showed higher grain yield (4864 ± 303 kg/ha) compared to IR58025B (4600 ± 377 kg/ha) and IR65 (3483 ± 627 kg/ha). Among the male parents, TDK1 had the highest yield (4813 ± 740 kg/ha), followed by TDK3 (4717 ± 255 kg/ha) and LNT1 (4633 ± 433 kg/ha). Hybrid (IR75589-31-27-8-33S/TDK6) has the highest grain yield with (5397 kg/ha) while the lowest yield was observed in hybrid (IR65/TDK9) with 2146 kg/ha (Table 1). The grain yield of the parents ranged from 2648 kg/ha (TDK9) to 4631 kg/ha (TDK33-9). Three out of 38 hybrids have significantly higher yield compared to the better parent and 18 out of 19 hybrids have significantly higher yield compared to the male parent.

Heterosis for grain yield. Table 2 presents the magnitude of heterobeltiosis for grain yield of the 19 hybrids derived from IR58025B crossed with Lao HYVs ranged from -14% to 12%, this is lower than the reported heterosis by many workers (Purohit, 1972; Palaniswamy and Palaniswamy, 1973; Sivasubramaniam and Menon, 1973; Mohanty and Mohapatra, 1973; Virmani

et al., 1981) which ranged from -90.7% to 161%. Out of the 19 hybrids evaluated, 9 hybrids showed positive heterobeltiosis for grain yield but lower than 15%. The highest magnitude of heterobeltiosis (12%) was observed in IR58025B/TDK1 and the lowest was detected in IR58025B/TDK37-B-9-1-3-B with -14%. The average performance of IR58025B for heterobeltiosis when crossed to 19 Lao HYVs was relatively low 0 ± 8%. This indicates that, IR58025B had low general combining ability (GCA), due to low heterobeltiosis. However, some hybrids showed positive heterobeltiosis, indicating a specific combining ability (SCA) to the specific male parent. The hybrid which had 8% heterobeltiosis had grain yield of 4965 kg/ha, which is significantly higher than TDK1 (4416 kg/ha), the most popular cultivar in Lao PDR. Therefore, IR58025A and IR58025B could be important sources of breeding materials for future waxy hybrid rice development.

The magnitude of heterobeltiosis for the grain yield of the 19 hybrids derived from the crosses of IR65 with Lao HYVs ranged from -39% to 25%. Out of the 19 hybrids evaluated, two hybrids (IR65/47-3-6-1-2-B and IR65/TDK37-B-3-2-1) showed positive heterobeltiosis, 24% and 25%, respectively. Six hybrids showed positive heterobeltiosis but lower than 15%. The mean performance of IR65 for heterobeltiosis when crossed with 19 Lao HYVs was relatively low -3% ± 15% . Similarly, IR65 had very low GCA, even though, some hybrids showed positive heterobeltiosis at 24% (4103 kg/ha) and 25% (4056 kg/ha), but their yield was lower than TDK1 (4416 kg/ha).

The magnitude of heterosis over male parent for the grain yield of the 19 hybrids derived from the crosses of R75589-31-27-8-33S with Lao HYVs ranged from -1% to 99%. Most of hybrids derived from IR75589-31-27-8-33S showed positive heterosis. Seventeen hybrids outyielded the male parent by 20% to 99%. The highest heterosis over male parent was observed in IR75589-31-27-8-33S/TDK9 (99%), while the lowest (-1) was observed in IR75589-31-27-8-33S/TDK33-9. The mean performance of IR75589-31-27-8-33S for heterosis over male parent was relatively high 38 ± 22%. The results suggest that IR75589-31-27-8-33S had high GCA.

In general, the mean heterosis for grain yield of the hybrids derived from IR75589-31-27-8-33S was higher compared to IR58225B and IR65 as female parents. Therefore, the two-line system may be adopted for further development of waxy hybrid rice in Lao PDR, where fertility and sterility of the TGMS line can be promoted in the northern,

and central and southern parts of the country, respectively. Positive heterosis was observed in hybrids involving the three female parents when crossed with TDK3, TDK5, LNT1 and TDK37-B-3-2-1. The heterosis however was low (2-9%) when IR65 and IR58025B were used as female parents compared to heterosis observed when IR75589-31-27-8-33S was used in the cross.

Evaluation of Grain Quality

Milling quality. Milling recovery is one of the most important criteria of rice quality, especially from a marketing stand point (Graham, 2002). A good variety should possess a high turn out of whole grain (head) rice and total milled rice (Webb 1985). In this study, head rice recovery of the hybrids ranged from 43% (IR65/TDK1) to 67% (IR75589-31-27-8-33S/TDK3), while the parents ranged from 46% (TDK42-B-4-3) to 65% (TDK3). Twenty hybrids had head rice recovery ranging from 60% to 65 (Table 3). The mean head rice recovery of the hybrids is 61 ± 4%, 58 ± 4% and 58 ± 5%, when the female parent used is IR75589-31-27-8-33S, IR58025B and IR65, respectively. This means that all female parents generated hybrids with high head rice recovery. The highest mean head rice recovery of the hybrids is 63 ± 3% and 63 ± 2%, when the male parents used is TDK3 and TDK5, respectively. TDK25-B-51-1-1-B generated hybrids with the lowest head rice recovery (52 ± 5%).

Amylose content (AC). AC is the most important criterion of grain quality of milled rice and is an indicator of amylose/amylopectin ratio. Amylose content of waxy hybrids rice and parents ranged from 0% to 2%, while non-waxy hybrids and parents ranged from 7% to 32% (Table 4). Three non-waxy hybrids, namely IR58025B/TDK 33-9, IR75589-31-27-8-33S/TDK33-9 and IR75589-31-27-8-33S/TDK43-B-51-1-1-B had 26%, 30% and 31% amylose, respectively. The male parents, TDK34-B-51-1-1-B and TDK33-9 of these hybrids have high AC, 28% and 32%, respectively. Eighteen, 9 and 11 hybrids have intermediate, low and very low amylose content ranging from 20% to 25%, 10% to 19% and 7% to 9%, respectively. However, amylose content was almost absent in waxy hybrids rice and the parents, only 2 hybrids (IR65/TDK42-B-4-3 and IR65/TDK37-B-3-2-1) had amylose content at 2%. The mean amylose content of the female parents are from 3 ± 8 (IR65); 11 ± 6 (IR58025B) and 22 ± 3% (IR75589-31-27-8-33S), while that of the male parents ranged from 9 ± 8% for TDK42-B-4-3 to 25 ± 6% for TDK34-B-51-1-1-B. In general, the results show that hybrids derived from the crosses among waxy with low amylose parents have low to very low amylose content. The

crosses among waxy with intermediate or high amylose parents generated hybrids with intermediate amylose content. The crosses among low amylose with intermediate or high amylose parents generated hybrids with intermediate to high amylose content, and the crosses among intermediate amylose with high amylose parent generated hybrids with high amylose content, due to, genes for high amylose content were dominant over intermediate and low amylose content.

Gel consistency (GC). GC is a good index of cooked rice texture. In this study, all hybrids and parents have soft GC ranging from 61 mm to 100 mm (Table 5). Three hybrids namely, IR75589-31-27-8-33S/ TDK34-B-51-1-1-B, IR75589-31-27-8-33S/ TDK33-9 and IR58025B/TDK33-9 have soft GC with 61 mm, 91 mm and 100 mm, respectively, but their amylose content is 31%, 30% and 26%, respectively. This results were similar to the parents (TDK33-9 and TDK34-51-1-1-B) having high AC at 32% and 28%, respectively, but with soft GC at 100 mm and 84 mm, respectively. Nevertheless, this result was contrary to the findings by Tang et al 1989, who found out that the varieties with high AC appeared to have hard gel consistency. However, varieties with intermediate and low amylose exhibited soft gel consistency. The mean GC of the female parents is 85 ± 8 mm (IR75589-31-27-8-33S), 98 ± 5 mm (IR65) and 98 ± 5 mm (IR58025B), meaning all female parents generate hybrids with soft GC. The mean GC of the male parents ranged from 76 ± 13 mm (TDK34-B-51-1-1-B) to 98 ± 3 mm (TDK 9), which is similar to the female parents and generated hybrids with soft gel consistency (Table 5). In general, parents which have soft GC would also give hybrids with soft GC, all hybrids have soft GC since all parents used in this study have soft GC.

Gelatinization Temperature (GT). ***GT*** is associated with cooking time and the texture of the cooked rice. Rice cooked by steaming does not absorb much water and the relationship between GT and time required for steaming is unknown. In this study, GT of hybrids and parents ranged from 59^{o}C to 75^{o}C (Table 6). Based on the classification of GT, three hybrids, IR58025B/TDK33-9, IR75589-31-27-8-33S/TDK33-9, and IR65/TDK33-9 have high GT. Eight hybrids have intermediate GT. Forty-six hybrids (17 waxy) have low GT and the lowest GT was observed in IR58025B/PNG1. The mean GT of the female parents ranged from 67 ± 3ºC (IR75589-31-27-8-33S); 68 ± 3ºC (IR58025B) and 69 ± 2ºC (IR65), while mean GT of the male parents ranged from 65 ± 3 (TDK34-B-51-1-1-B) to 75 ± 0ºC (TDK33-9). This means both parents evaluated in this study generated hybrids with low GT.

In general, hybrids derived from the crosses between varieties with high GT and low GT parents generate hybrids with high GT. The crosses between varieties with intermediate GT generated low and intermediate GT hybrids and the crosses between low GT generated low GT hybrids. The hybrids which have high GT have high AC.

Eating quality test (EQ). Evaluation eating quality for both waxy and non-waxy rice was classified as: soft, medium and hard taste. Among the waxy hybrids, two (IR65/TDK5 and IR65/TDK9) were rated as soft, 9 were rated as medium and 3 were rated as hard (Table 7). The mean percentage of EQ of the hybrids was rated medium (46±15%) when IR 65 was used as female parent. However, some hybrids with soft taste were highly preferred by the panel. In general, the panel evaluated the hybrids as having medium taste. This indicated that waxy hybrids are acceptable to the Lao people.

Among non-waxy hybrids, 18 hybrids were rated soft, 23 were rated medium and only two were rated as hard. Almost 90% of hybrids had soft to medium texture in the non-waxy hybrids (Table 8). Results show that lower variation among the panel's evaluation of eating quality of the non-waxy hybrids. They were also acceptable to the panel meaning that the non-waxy hybrids are acceptable to Lao's evaluation panel.

It was also found out that, the soft, medium and hard taste category of the waxy hybrid rice which was preferred by Lao consumers was not associated with low amylose content (Figure 1). In this study, two waxy hybrids rice, which have low AC (0% to 2%) and high GC (100%) were rated as hard. The soft, medium and hard taste of non-waxy rice was associated to low, medium and high amylose content (Figure 2). Since most of the hybrids in this study were rated as soft and medium taste, hence they also had low to medium amylose content. Since hybrids derived from the crosses between low AC parents with waxy parents were rated as soft to medium by the panel, this indicated that the non-waxy hybrids rice is also acceptable to Lao people.

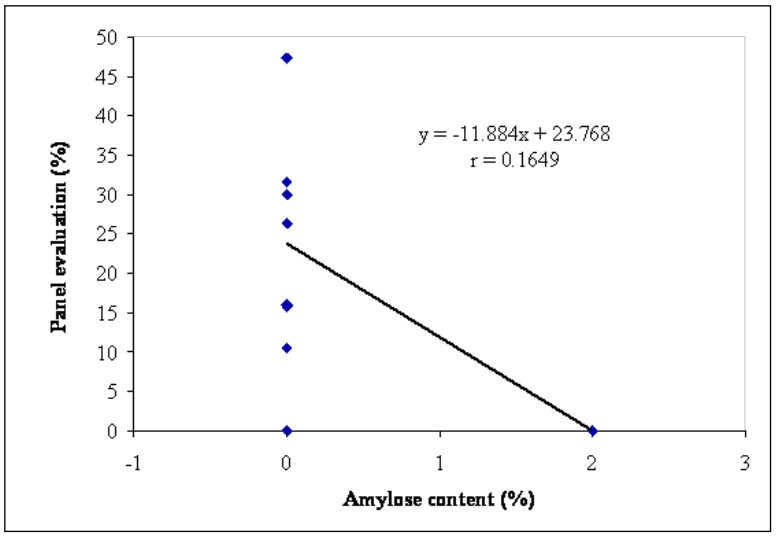

Fig. 1: Relationship between AC and EQ of waxy rice.

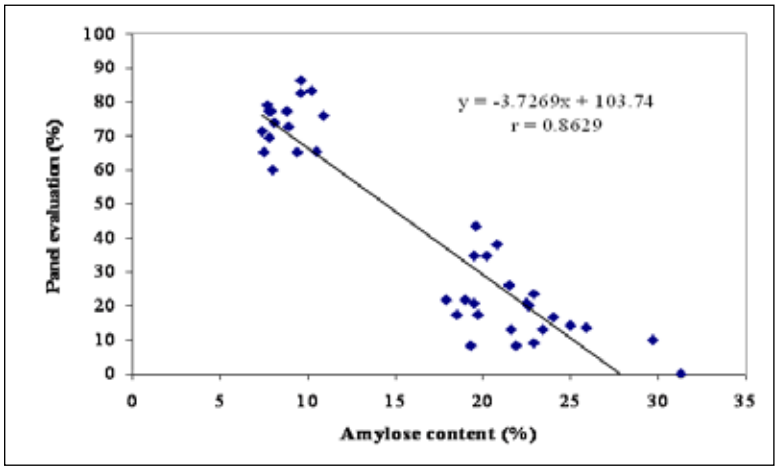

Fig. 2: Relationship between AC and EQ of Non-waxy rice

IV. Conclusion and Recommendations

Based of the results of the experiment the following conclusions and recommendations were made. The mean heterobeltiosis of IR58025B crossed with 19 Lao HYVs was low (0 ± 8%). However, some hybrids though showed positive heterobeltiosis indicating the presence of a specific combining ability to the specific male parent. Therefore, the CMS-WA line, IR58025A and its maintainer line, IR58025B can be useful breeding materials for future waxy hybrid rice research in Lao PDR.

The mean performance of hybrids involving a TGMS line, IR75589-31-27-8-33S for and the Lao HYVs was high (38 ± 22%) and most of hybrids derived from IR75589-31-27-8-33S gave heterosis over male parent. This means IR75589-31-27-8-33S has a good general combining ability, therefore, this TGMS line should be considered as a source of breeding materials for two-line hybrid rice breeding program in the Lao PDR.

The mean performance of hybrids involving IR65 and the 19 Lao HYVs was relatively low (-3% ± 15), two hybrids though gave 24% and 25% heterosis indicating specific combining ability. IR65 therefore could also be tapped for waxy hybrid rice research in the future.

The crosses between low amylose parent (IR58025B) with waxy parents generated hybrids with low amylose content. Therefore, for hybrid waxy rice development, both parental sources should be of low amylose content (waxy).

The sensory panel, the soft, medium and hard taste of waxy rice is preferred by Lao consumers. This is however not associated with amylose content. In breeding for waxy rice, the preferred eating quality (soft texture) should be considered. For non-waxy rice, the soft, medium and hard texture was associated to low, medium and high amylose content. The hybrids in the study that were rated as soft had also low amylose content.

To develop waxy hybrid rice using the two-line system, the thermo-sensitive genic male sterility system (TGMS) of IR75589-31-27-8-33S and other lines should to be transferred to the back ground of waxy rice. For the three lines hybrid system, the waxy maintainer and restorer lines should be identified from the Lao germplasm, before the desirable gene from IR58025A or other lines under this system will be transferred in to the back ground of waxy rice.

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VII. Annexes

Table 1: Mean performance of the parents for the grain yield of F1 hybrids (kg/ha)

MALE PARENTS	FEMALE PARENTS			MEAN ± SD$\bar{x}$
	IR58025B (4610)	IR65 (2705)	IR75589-31-27-8-33S	
TDK 1 (4416)	5175*	3962	5304*	4813 ± 740
TDK 3 (4341)	4971	4461	4720*	4717 ± 255
TDK 5(2896)	4692	3057	4585*	4111 ± 915
TDK 6 (4274)	4965	3296	5397*	4553 ±1.110
TDK 7 (3850)	4488	3738	4825*	4350 ± 556
TDK 9 (2648)	4037	2146	5263*	3815 ± 1.570
PNG 1 (3760)	4486	3503	4923*	4304 ± 728
PNG 3 (3709)	5041	2264	4919*	4075 ± 1.569
PNG 6 (3777)	4984	3572	4704*	4420 ±749
TSN 1 (3177)	4395	3457	4554*	4135 ± 593
NTN 1 (3201)	4393	3363	5043*	4266 ± 847
LNT 1 (4042)	4820	4138	4941*	4633 ± 433
TDK37-B-3-2-1 (3246)	5028	4056*	4559*	4548 ± 486
TDK47-3-6-1-2-B (3319)	4589	4103*	5151*	4614 ± 524
TDK49-B-9-1-3-B (3695)	3950	3356	5177*	4161 ± 929
TDK25-B-14-3-B (3115)	4099	2804	4432*	3778 ± 860
TDK33-9 (4631)	4730	4281	4580	4530 ± 228
TDK42-B-4-3 (3058)	4442	3310	4926*	4226 ± 830
TDK43-B-51-1-1-B (3459)	4116	3309	4414*	3946 ± 572
MEAN ± SD$\bar{x}$	**4600 ± 377**	**3483 ± 627**	**4864 ± 303**	

Number enclosed in parenthesis is the grain yield of the parents.

LSD 5% = 466

*Significant at LSD 5% compared to better parent for the crosses of IR58025B and R65, and compared to the male parent of the cross of IR57789-31-27-8-33S.

Table 2: Percentage of the mean performance of the parents for heterosis/heterobeltiosis of the hybrids (%).

MALE PARENTS	FEMALE PARENTS			MEAN ± SD$\bar{x}$
	IR58025B	IR65	IR75589-31-27-8-33S*	
TDK 1	12	-10	20	7 ± 16
TDK 3	8	3	9	6 ± 3
TDK 5	2	6	58	22 ± 32
TDK 6	8	-23	26	4 ± 25
TDK 7	-3	-3	25	7 ± 16
TDK 9	-12	-19	99	22 ± 66
PNG 1	-3	-7	31	7 ± 21
PNG 3	9	-39	33	1 ± 37
PNG 6	8	-5	25	9 ± 15
TSN 1	-5	9	43	16 ± 25
NTN 1	-5	5	58	19 ± 33
LNT 1	5	2	22	10 ± 11
TDK37-B-3-2-1	9	25	40	25 ± 16
TDK47-3-6-1-2-B	0	24	55	26 ± 28
TDK49-B-9-1-3-B	-14	-9	40	6 ± 30
TDK25-B-14-3-B	-11	-10	42	7 ± 30
TDK33-9	3	-8	-1	-2 ± 5
TDK42-B-4-3	-4	8	61	22 ± 34
TDK43-B-51-1-1-B	-11	-4	28	4 ± 21
MEAN ± SD$\bar{x}$	**0 ± 8**	**-3 ± 15**	**38 ± 22**	

Table 3: Mean performance of the parents for the head rice recovery to F1 hybrids.

MALE PARENTS	FEMALE PARENTS			MEAN ± SD$\bar{x}$
	IR58025B (56)	IR65 (59)	IR75589-31-27-8-33S	
TDK 1 (62)	62	43	59	55 ± 11
TDK 3 (65)	61	62	67	63 ± 3
TDK 5 (59)	61	61	65	63 ± 2
TDK 6 (62)	60	60	59	60 ± 1
TDK 7 (63)	57	63	64	62 ± 4
TDK 9 (57)	56	61	56	58 ± 3
PNG 1 (61)	59	63	64	62 ± 3
PNG 3 (62)	64	59	61	62 ± 2
PNG 6 (62)	57	60	58	59 ± 2
TSN 1 (57)	59	57	61	59 ± 2
NTN 1 (59)	62	54	62	59 ± 5
LNT 1 (59)	62	55	60	59 ± 3
TDK37-B-3-2-1 (49)	59	57	64	60 ± 4
TDK47-3-6-1-2-B (54)	58	52	61	57 ± 4
TDK49-B-9-1-3-B (51)	52	58	54	55 ± 3
TDK25-B-14-3-B (55)	46	54	55	52 ± 5
TDK33-9 (62)	57	53	61	57 ± 4
TDK42-B-4-3 (46)	55	59	61	58 ± 3
TDK43-B-51-1-1-B (63)	55	62	65	61 ± 5
MEAN ± SD$\bar{x}$	**58 ± 4**	**58 ± 5**	**61 ± 4**	

Number enclosed in parenthesis is the head rice recovery of the parents.

Table 4: Mean performance of the parents for AC of F1 hybrids.

MALE PARENTS	FEMALE PARENTS			MEAN ± SD$\bar{x}$
	IR58025B (14%)	IR65 (0%)	IR75589-31-27-8-33S	
TDK 1 (1%)	10	0	19	10 ± 10
TDK3 (0%)	11	0	22	11 ± 11
TDK 5 (0%)	10	0	23	11 ± 11
TDK 6 (0%)	8	0	20	9 ± 10
TDK 7 (0%)	8	0	21	10 ± 10
TDK 9 (0%)	10	0	22	11 ± 11
PNG 1 (0%)	11	0	20	10 ± 10
PNG 3 (0%)	9	0	22	10 ± 11
PNG 6 (0%)	8	0	23	10 ± 12
TSN 1 (0%)	9	0	20	10 ± 10
NTN 1 (0%)	8	0	23	10 ± 12
LNT 1 (0%)	7	0	20	9 ± 10
TDK37-B-3-2-1 (0%)	8	2	20	10 ± 9
TDK47-3-6-1-2-B (0%)	9	0	22	10 ± 11
TDK49-B-9-1-3-B (22%)	23	19	24	22 ± 3
TDK25-B-14-3-B (0%)	8	0	20	9 ± 10
TDK33-9 (32%)	26	23	30	26 ± 3
TDK42-B-4-3 (0%)	8	2	18	9 ± 8
TDK43-B-51-1-1-B (28%)	25	19	31	25 ± 6
MEAN ± SD$\bar{x}$	**11 ± 6**	**3 ± 8**	**22 ± 3**	

Number enclosed in parenthesis is the % amylose content of the parents.

Table 5: Mean performance of the parents for GC of F1 hybrids.

MALE PARENTS	FEMALE PARENTS			MEAN ± SD$\bar{x}$
	IR58025B (94)	IR65 (100)	IR75589-31-27-8-33S	
TDK 1 (100)	99	100	89	96 ± 6
TDK 3 (100)	100	100	84	95 ± 10
TDK 5 (100)	100	100	88	96 ± 7
TDK 6 (100)	100	100	91	97 ± 5
TDK 7 (100)	100	100	86	95 ± 8
TDK 9 (100)	100	100	95	98 ± 3
PNG 1 (100)	100	100	88	96 ± 7
PNG 3 (100)	100	100	82	94 ± 11
PNG 6 (100)	100	100	75	92 ± 14
TSN 1 (100)	99	100	91	97 ± 5
NTN 1 (100)	100	100	73	91 ± 16
LNT 1 (100)	100	100	89	96 ± 6
TDK37-B-3-2-1 (100)	99	100	85	95 ± 8
TDK47-3-6-1-2-B (100)	100	100	92	97 ± 5
TDK49-B-9-1-3-B (100)	84	89	89	87 ± 3
TDK25-B-14-3-B (100)	97	100	90	96 ± 5
TDK33-9 (100)	100	100	91	97 ± 5
TDK42-B-4-3 (100)	99	100	87	95 ± 7
TDK43-B-51-1-1-B (100)	85	82	61	76 ± 13
MEAN ± SD$\bar{x}$	**98 ± 5**	**98 ± 5**	**85 ± 8**	

Number in parenthesis is the GC content of the parents.

Table 6: Mean performance of the parents for GT of F1 hybrids.

MALE PARENTS	FEMALE PARENTS			MEAN ± SD$\bar{x}$
	IR58025B (69)	IR65 (69)	IR75589-31-27-8-33S	
TDK 1 (70)	69	69	67	68±1
TDK 3 (71)	69	69	67	69±1
TDK 5 (70)	69	69	66	68±2
TDK 6 (67)	68	69	67	68±1
TDK 7 (70)	70	69	67	68±2
TDK 9 (70)	69	68	62	66±3
PNG 1 (71)	59	69	68	65±5
PNG 3 (70)	69	69	67	68±1
PNG 6 (71)	69	67	67	68±1
TSN 1 (70)	70	68	69	69±1
NTN 1 (71)	67	70	67	68±2
LNT 1 (70)	70	68	67	68±1
TDK37-B-3-2-1 (71)	70	70	67	69±1
TDK47-3-6-1-2-B (70)	70	68	66	68±2
TDK49-B-9-1-3-B (66)	66	66	62	64±2
TDK25-B-14-3-B (70)	69	69	68	69±1
TDK33-9 (75)	75	75	75	75±0
TDK42-B-4-3 (71)	70	68	68	69±1
TDK43-B-51-1-1-B (67)	61	66	67	65±3
MEAN ± SD$\bar{x}$	**68 ± 3**	**69 ± 2**	**67 ± 3**	68 ±

Number enclosed in parenthesis is the GT of the parents.

Table 7: Percentage of the panel evaluation of F1 waxy hybrids and parents/checks.

Male parents	IR65		
	Soft taste	Medium taste	Hard taste
TDK 1	11	37	53
TDK 3	32	32	37
TDK 5	47	37	16
TDK 6	32	58	11
TDK 7	32	53	16
TDK 9	47	42	11
PNG 1	16	63	21
PNG 3	11	53	36
PNG 6	30	45	25
TSN 1	11	72	17
NTN 1	16	58	26
LNT 1	16	42	42
TDK37-B-3-2-1	0	11	89
TDK47-3-6-1-2-B	26	53	21
TDK25-B-14-3-B	32	53	16
TDK42-B-4-3	0	28	72
Max	47	72	89
Min	0	11	11
$MEAN \pm SD\bar{x}$	**26 ± 13**	**45 ± 13**	**29 ± 18**

Table 8: Percentage of panel evaluation of F1 non-waxy hybrids rice and parents/checks.

Male parents	IR58025B			IR75589-31-27-8-33S			IR65		
	Soft	Medium	Hard	Soft	Medium	Hard	Soft	Medium	Hard
TDK 1	77	23	0	22	61	17	-	-	-
TDK 3	77	23	0	13	78	9	-	-	-
TDK 5	77	23	0	21	63	17	-	-	-
TDK 6	77	23	0	21	66	14	-	-	-
TDK 7	77	18	5	38	48	14	-	-	-
TDK 9	77	23	0	26	43	30	-	-	-
PNG 1	68	27	5	35	35	30	-	-	-
PNG 3	77	23	0	8	63	29	-	-	-
PNG 6	73	23	5	9	59	32	-	-	-
TSN 1	68	32	0	43	43	13	-	-	-
NTN 1	77	23	0	24	53	24	-	-	-
LNT 1	68	32	0	35	43	22	-	-	-
TDK37-B-3-2-1	65	26	9	17	65	17	-	-	-
TDK47-3-6-1-2-B	73	27	0	13	65	22	-	-	-
TDK49-B-9-1-3-B	20	52	28	17	58	25	17	48	35
TDK25-B-14-3-B	74	26	0	35	52	13	-	-	-
TDK33-9	14	55	32	10	30	60	13	52	35
TDK42-B-4-3	58	29	13	22	65	13	-	-	-
TDK43-B-51-1-1-B	14	48	38	0	33	67	8	54	38
Max	77	55	38	43	78	67	17	54	38
Min	14	18	0	0	30	9	8	48	35
MEAN $\pm$ SD$\bar{x}$	**64±22**	**29±11**	**7±12**	**21±12**	**54±13**	**25±15**	**13±5**	**51±3**	**36±2**

ການຕີລາຄາທາງດ້ານຄຸນນະພາບ ເຂົ້າພັນປັບປຸງ ຂອງ ລາວ

ເພັດມະນີແສງ ຊ້າງໄຊຍະສານ[1]; Fangming Xie[2] ແລະ Teresita H. Borromeo[3]

ບົດຄັດຫຍໍ້

ເຂົ້າທີ່ມີຄຸນນະພາບດີ ຈະເປັນທີ່ຕ້ອງການຂອງຕະຫຼາດ ແລະ ຜູ້ບໍລິໂພກ. ປະຈຸບັນ ຄວາມຕ້ອງການເຂົ້າທີ່ມີຄຸນນະພາບດີນັ້ນ ເຫັນວ່ານັບມື້ນັບເພີ່ມຂຶ້ນ ແຕ່ວ່າ ເຂົ້າທີ່ມີຄຸນນະພາບນັ້ນ ຈະປະກອບດ້ວຍຫຼາຍໆປັດໄຈ ເຊັ່ນ: ຮູບຮ່າງຂອງເມັດເຂົ້າ, ສີຂອງເມັດ, ທາດອາຫານທີ່ມີໃນເມັດເຂົ້າ ຕະຫຼອດຮອດຄຸນນະພາບຂອງການຫຸງຕົ້ມ ແລະ ຄຸນນະພາບທາງດ້ານການກິນ. ຈຸດປະສົງໃນການສຶກສານີ້ ແມ່ນ: (1) ຕີລາຄາ ທາງດ້ານເຄມີ, ດ້ານກາຍະພາບ ແລະ ທາງຄຸນນະພາບການກິນ ຂອງເຂົ້າພັນປັບປຸງທີ່ໃຫ້ຜົນຜະລິດສູງ ຂອງລາວ ແລະ (2) ສຶກສາຄວາມສຳພັນລະຫວ່າງຄຸນນະພາບການກິນ ແລະ ເປີເຊັນຂອງທາດອາມີໂລ ທີ່ມີໃນເມັດເຂົ້າ. ຜົນຂອງການສຶກສາພົບວ່າ ເປີເຊັນເຂົ້າສານທີ່ສີໄດ້ທັງໝົດ ສັງເກດໄດ້ແຕ່ 65% ຫາ 70%, ໃນຂະນະທີ່ ເປີເຊັນເຂົ້າສານເມັດເຕັມ ສັງເກດໄດ້ແຕ່ 46% ຫາ 65%. ເປີເຊັນຂອງທາດອາມີໂລ ທີ່ພົບໃນເມັດເຂົ້າໜຽວ ສັງເກດໄດ້ແຕ່ 0% ຫາ 1% ແລະ ພົບໃນເມັດເຂົ້າຈ້າວແຕ່ 22% ຫາ 32%. ຄ່າຄວາມໜຽວຂອງອຸ້ມ ແຕ່ 84 ມມ ຫາ 100 ມມ. ອຸນຫະພູມໃນການຫຸງຕົ້ມ ແຕ່ 67°C ຫາ 71°C. ຄຸນນະພາບການກິນ ຂອງເຂົ້າໜຽວພົບວ່າ ມີຄວາມແປປວນ ແລະ ບໍ່ມີຄວາມສຳພັນກັບເປີເຊັນອາມີໂລ ທີ່ມີໃນເມັດເຂົ້າ ແຕ່ຄຸນນະພາບການກິນ ຂອງເຂົ້າຈ້າວ ພົບວ່າ ມີຄວາມສຳພັນກັບເປີເຊັນອາມີໂລ ທີ່ມີໃນເມັດເຂົ້າ. ເຂົ້າຈ້າວ ທີ່ມີທາດອາມີໂລຕ່ຳ ຈະເປັນທີ່ນິຍົມຂອງຜູ້ບໍລິໂພກ ຂອງຊາວລາວ. ດັ່ງນັ້ນ ການປັບປຸງ ແລະ ຜະລິດເຂົ້າຈ້າວ ສາຍພັນໃໝ່ ນັ້ນ ຈະຕ້ອງໄດ້ຄຳນຶງເຖິງສ່ວນປະກອບ ຂອງທາດອາມີໂລ ທີ່ມີຢູ່ນຳເມັດເຂົ້າສານດ້ວຍ.

Key words: *grain quality, amylose content, gel consistency, gel temperature, waxy rice, eating quality.*

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Grain Quality Evaluation of Lao High Yielding Cultivars

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Abstract

Rice quality is one of the most important characters as it exerts large effects on the market value and consumer acceptance. The demand for high quality rice cultivars is increasing owing to recent changes in consumer preferences and strong market requirement. Grain quality of rice is determined by many factors such as grain appearance, nutritional value, amylose content, gel consistency, gelatinization temperature, cooking and eating qualities. The objectives of this research are (1) to evaluate chemical, physical and cooking quality of Lao High Yielding Cultivars and (2) to evaluate the relationship between amylose content and eating quality. Total milled rice recovery ranged from 65% to 70%, while head rice recovery ranged from 46% to 65%. Amylose content of waxy rice ranged from 0% to 1%, while non waxy rice ranged from 22% to 32%. Gel consistency ranged from 84 to 100 mm. Gelatinization temperature ranged from 67^{o}C to 71^{o}C. Eating quality of waxy rice was not associated with amylose content, while non waxy rice was associated with amylose content. There for, breeding for non waxy rice in the further, low amylose content should be considered; due to Lao consumers prefer low amylose rice.

Key worlds: grain quality, amylose content, gel consistency, gel temperature, waxy rice, eating quality.

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I. Introduction

Grain quality has probably used as a criterion to select rice since human first cultivated it. Consumers purchase rice based on quality characters and attach higher implicit prices to these attributes. Development of cultivars with good grain qualities is an important objective of rice improvement program today, and its relevance is much greater (Pingali *et al* 1997). For the rice breeding program in Laos, grain quality is the key role in research from the rice breeding program has begun. The increased yield of improved rice cultivar alone does not ensure profitability to farmers if grain quality is not acceptable. Major determinants of rice grain quality are (1) hull and pericarp color, (2) grain size, shape, weight uniformity and general appearance, (3) milling and head rice recovery, (4) grain chalkiness, translucency and color, and (5) cooking, eating and processing characteristics. Among the above quality traits, apparent amylose content (AC), gel consistency (GC), and gelatinization temperature (GT) are recognized as the most important determinants of rice eating and cooking qualities (Cagampang *et al*., 1973; Juliano, 1971; McKenzie and Rutger, 1983; Little *et al*., 1958; Tan *et al*., 1999; Webb, 1980).

AC is the most important criterion of grain quality of milled rice and is an indicator of amylose/amylopectin ratio. It is usually expressed as a percentage of milled rice dry weight rather as starch basis (Juliano, 1979). Based on the amylose content, the rice varieties are classified as waxy (0%-2%) and nonwaxy (>2%). Non waxy rice is categorized into four groups: very low amylose (3%-9%), low (10%-19%), intermediate (20%-25%) or high (> 25%) amylose content (Kumar and Khush, 1986a, 1987, 1988, Khush *et al*., 1979; Dala Cruz and Khush, 2000).

GC in rice differs in gel consistency from soft to hard (Cagampang *et al*., 1973). GC test is a good index of cooked rice texture; the test is based on the consistency of milled rice paste that has been gelatinized by boiling dilute alkali and then cooled to room temperature (Cagampang *et al*., 1973; Juliano, 1979). Gel consistency is classified as hard (<35 mm), medium hard (36-40 mm), medium (41-60 mm), and soft (60-100 mm). Rice with soft GC is tender and remains soft after cooking (Juliano, 1979).

GT is defined as the range of temperature at which nearly all the starch granules start to swell irreversibly in hot water with simultaneous loss of birefringence and crystallinity. Generally, rice varieties with

high GT, requires more water and time for cooking. Gelatinization temperature can be grouped broadly in to three classes: low (less than 70^0C), intermediate (70^0C - 74^0C), and high (more than 74^0C) (Beachell and Stansel, 1963). The objective of the research is (1) to evaluate grain quality (chemical quality and cooking quality) of Lao High Yielding Cultivars.

II. Matrials and Methods

Planting materials

A total of nineteen Lao High Yielding Cultivars (LHYC), sixteen waxy and three non-waxy were evaluated (Table 1). All cultivars were grown under irrigated lowland condition during dry season, 2008 at IRRI farm. Fertilizer rate of 100:40:30 kg/ha (N-P-K) was applied. Weeds were controlled by hand weeding. Rice grain sample was harvested at ripening stage for evaluation of grain quality. The samples were collected after threshing, cleaning and drying to 14% moisture content.

Grain quality evaluation

Chemical quality was done in grain quality laboratory, IRRI, while physical andeating quality was done in Rice and Cash Crop Research Center.

Milling quality (MQ). A 125g of rough rice sample with moisture content of approximately 12% to 14% was used to determine milling recovery. Rough rice sample was dehulled by using a Satake laboratory sheller. Brown rice was recorded before milling in a McGill mill number 2 for one minute. The milled rice sample was collected in a jar and was allowed to cool before weighing; the weight of the total milled rice was recorded. Whole grains (head rice) were separated from the total rice with rice-sizing device and recorded. The percentage of milling recovery was calculated as follows:

$$\text{Brown rice } (\%) = \frac{\text{Weight of brown rice}}{\text{Weight of rough rice}} \times 100$$

$$\text{Total milled rice } (\%) = \frac{\text{Weight of Total milled rice}}{\text{Weight of rough rice}} \times 100$$

$$\text{Head rice } (\%) = \frac{\text{Weight of Head rice}}{\text{Weight of rough rice}} \times 100$$

Amylose content (AC). The milled rice sample was ground in an Udy cyclone mill (sieve mesh size 60), and 100 mg of rice powder was put into a 100 ml volumetric flash. One ml of 95% ethanol and nine ml of 1M sodium hydroxide (NaOH) were added respectively. The contents were heated in a boiling water bath and then allowed to cool

for two hours before making up to 100 ml with distilled water. Five ml of the starch solution was put in a 100 ml volumetric flash with a pipette. One ml of 1M acetic acid and 2 ml of iodine solution (0.2 g iodine and 2 g potassium iodine in 100 ml aqueous solution) were added and the volume was made up with distilled water. The contents were mixed using a vortex genie mixer and left to stand for 20 minutes. Absorbance of solution was measured at 620 mm with an AutoAnalyser (Autoanalyser 3 Bran+Luebbe). Amylose content was calculated by comparison with the absorbance of the standards, namely IR29, IR24, IR64 and IR8.

Gelatinization temperature (GT). GT was measured by Differential Scanning Calorimetry (DSC) (DSC Q100, TA Instruments). The samples were ground in an Udy cyclone mill (sieve mesh size 60), and 4 mg of powder was mixed with water (8 ml) in an aluminum hermetic pan, and then the pans were sealed before heated under pressure from 35˚C - 100˚C in increments of 10˚C/min in the DSC. The gelatinization temperature was determined from the peak of the endotherm.

Gel consistency (GC). The milled rice sample and check (hard, medium and soft gel rice varieties) were ground in the Udy cyclone mill (sieve mesh size 100), and 100 mg of rice powder was weighed in duplicate into the culture tubes (13 mm x 100 mm). Ethyl alcohol (0.2 ml of 95%) containing 0.025% thymol blue and 2 ml of 0.2M KOH were added with a pipette, respectively. The contents were mixed using a vortex genie mixer before cooking in a vigorously boiling water bath for 8 minutes, and left to stand at room temperature for 5 minutes, and then the tubes were cooled in ice-water bath for 20 minutes. Then, the tubes were laid horizontally on the laboratory table lined with millimeter graphing paper. The length of gel was measured in millimeters (mm) from the bottom of the tube to the gel front.

Eating quality (EQ). EQ was done based on endosperm type. For glutinous hybrids, the milled grains and the checks were soaked in water for 3 hours, followed by steam cooking for 30 minutes in the woven bamboo basket (1 sample/basket). For non-glutinous rice, milled grains and checks were steam cooked for 30 minutes at the water-rice ratio of 1:1 (1 sample/beaker). All samples were cooked using the similar techniques and duration of cooking. Tactile senses were tested based on standard descriptor (soft; medium and hard). A sensory panel composed of 40 farmers and researchers were invited for sensory evaluation. The preference test was completed over a period of 2 days with one replication being completed in a day. Samples were numbered and presented to

the panel. For assessing quality using non-visual perceptions, they were blind-folded so that they will not be biased by the visual appearance of the rice sample.

III. Results and Discusion

Milling quality (MQ). Milling recovery is one of the most important criteria of rice quality, especially from a marketing stand point (Graham, 2002). A good variety should possess a high turn out of whole grain (head) rice and total milled rice (Webb 1985). In this study, total milled rice ranged from 60% (TDK37-B-3-2-1) to 70% (TDK43-B-51-1-1-B, PNG6 and TDK7). Head rice recovery ranged from 46% (TDK42-B-4-3) to 65% (TDK3). The highest head rice recover was observed in TDK3 with 65% and TDK7 with 63%. Nine cultivars had head rice recover ranging from 61% to 65%; this is the most desirable trait of the new high yielding cultivars, which have high head rice recovery. Eight cultivars had head rice recover ranging from 51% to 57% and 2 cultivars had head rice recover ranging from 46% to 49% (Table 2).

Amylose content (AC). AC is the most important criterion of grain quality of milled rice and is an indicator of amylose/amylopectin ratio. Amylose content of waxy rice in this study ranged from 0% to 1%, while non-waxy ranged from 22% to 32% (Table 3). Amylose content of non waxy rice (TDK43-B-51-1-1-B, TDK34-B-51-1-1-B and TDK33-9) was observed from 22%, 28% and 32%, respectively, while almost of waxy rice had AC of 0%, accept TDK1 has 1%. AC of non waxy rice, which was developed by Lao National Rice breeding Program, was classified at intermediate (22%) to high (28% to 32%).

Gel consistency (GC) is a good index of cooked rice texture. In this study, all cultivars (waxy and non waxy) have soft GC ranging from 84 mm to 100 mm (Table 3). These mean that all LHYC have soft gel consistence. TDK33-9 and TDK43-51-1-1-B having high AC at 32% and 28%, respectively, but with soft GC at 100 mm and 84 mm, respectively. Nevertheless, this result was contrary to the findings by Tang et al 1989, who found out that the varieties with high AC appeared to have hard gel consistency. However, varieties with intermediate and amylose exhibited soft gel consistency.

Gelatinization Temperature (GT) is associated with cooking time and the texture of the cooked rice. Rice cooked by steaming does not absorb much water and the relationship between GT and time required for steaming is unknown. In this study, GT of LHYC (waxy and non waxy)

ranged from 66°C to 71°C (Table 3). Based on the classification of GT, three cultivars have low GT ranged from 66°C to 67°C and sixteen have intermediate GT ranged from 70°C to 75°C. TDK33-9 was classified as intermediate GT with 75°C, while two, non waxy rice (TDK49-B-9-1-3-B and TDK43-B-51-1-1-B) were classified as soft GT with 66°C and 67°C, respectively. These data show that, TDK33-9 would need more time and water for cooking compare to TDK49-B-9-1-3-B and TDK43-B-51-1-1-B.

Eating quality test (EQ). A total of 40 farmers and researchers were invited for sensory evaluation. Evaluation for both waxy and non-waxy rice was classified as: soft, medium and hard taste. Among the waxy rice, three were rated as soft (TDK7, PNG6 and TSN1), 12 were rated as medium and one were rated as hard. The mean percentage of EQ of the waxy rice was rated medium (47 ± 9%). These results show that most of waxy rice cultivars which were developed by the National Rice Breeding Program are accepted by the testers. However, there was variation in the sensory evaluation, due to difference tester prefer difference taste. In this study, one waxy rice, which have low AC (0%) and high GC (100%) was rated as hard. This main that, the soft, medium and hard taste category of the waxy rice which was preferred by Lao's consumers was not associated with low amylose content and high gel consistency.

Among non-waxy, one was rated medium, two were rated as hard (Table 5). Two checks used for comparison such as: KDML105 was rated as soft taste, while CR203 was rated as hard taste. The soft, medium and hard taste of non-waxy rice was associated to low, medium and high amylose content. Since the cultivars in this study were rated as medium and hard taste, hence they also had intermediate to high amylose content.

IV. Conclusion and Recommendation

Based on the results of the experiment, show that most of the LHYV, which were developed by the National Rice Breeding Program, have high head rice recovery for both waxy and non waxy rice. AC of waxy rice is always about 0% to 2% in modern improved cultivar and it may go up to 7% in traditional cultivars, while for non waxy rice it is ranging from 7% to 35% or even higher. Most of LHYV for both waxy and non waxy have soft gel consistency. The GT of LHYV ranged from intermediate to high. Sensory evaluation of the LHYC for waxy rice was rated as medium taste and for non waxy rice, sensory evaluation was rated as medium to

hard taste, due Lao people prefer low amylose rice. The evaluation of eating quality is quite difficult to evaluated, because it is measure by panel or sense of the testers and it always has variation among the testers; due to different testers prefer difference taste. Eating quality of waxy rice which was prefer by Lao testers was not associated with low amylose content and gel consistency, there for, breeding for waxy rice, panel evaluation is necessary before release a new cultivar. Eating quality of non waxy rice was associated with low amylose content, there for, breeding for non waxy rice, low amylose content with soft gel consistency should be considered.

V. Acknowledgement

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VII. Annexes

Table 1: Planting materials

PARENTS	ENDOSPERM YYPE	COUNTRY/SOURCE
TDK 1	Waxy	Laos
TDK 3	Waxy	Laos
TDK 5	Waxy	Laos
TDK 6	Waxy	Laos
TDK 7	Waxy	Laos
TDK 9	Waxy	Laos
PNG 1	Waxy	Laos
PNG 3	Waxy	Laos
PNG 6	Waxy	Laos
TSN 1	Waxy	Laos
NTN 1	Waxy	Laos
LNT 1	Waxy	Laos
TDK37-B-3-2-1	Waxy	Laos
TDK47-3-6-1-2-B	Waxy	Laos
TDK49-B-9-1-3-B	Non Waxy	Laos
TDK25-B-14-3-B	Waxy	Laos
TDK33-9	Non Waxy	Laos
TDK42-B-4-3	Waxy	Laos
TDK43-B-51-1-1-B	Non Waxy	Laos

Table 2: Milled rice recovery, Characteristic of paddy rice and 1,000 grain weight of LHYC.

Varieties	% HULL	% BR	%TMR	% HR	Length (mm)	Wide (mm)	1,000-grain weight (g)
TDK 1	24	76	68	62	10.4	2.9	31.5
TDK 3	23	77	69	65	9.7	2.8	26.5
TDK 5	24	76	67	59	9.8	2.8	27.8
TDK 6	22	78	69	62	9.0	2.6	31.9
TDK 7	21	79	70	63	11.4	2.7	31.0
TDK 9	25	75	65	57	10.8	2.8	35.3
PNG 1	25	75	66	61	11.0	2.7	31.5
PNG 3	24	76	67	62	9.7	2.7	27.4
PNG 6	22	78	70	62	11.1	2.8	31.6
TSN 1	23	77	65	57	9.7	2.6	27.2
NTN 1	24	76	66	59	11.0	2.8	30.9
LNT 1	25	75	68	59	10.9	2.8	30.7
TDK37-B-3-2-1	25	75	60	49	10.9	2.8	31.1
TDK47-3-6-1-2-B	24	76	66	54	10.7	2.7	31.4
TDK49-B-9-1-3-B	23	77	67	51	10.7	2.8	32.6
TDK25-B-14-3-B	24	76	66	55	10.9	3.3	31.4
TDK33-9	23	77	68	62	10.4	2.5	29.6
TDK42-B-4-3	24	76	66	46	10.9	3.2	29.9
TDK43-B-51-1-1-B	20	80	70	62	9.3	3.3	33.4

BR= Brown rice, TMR = total milled rice, HR= head rice.

Table 3: Chemical quality of Lao High Yielding Rice Cultivars.

CROSSIES NO	AC (%)	GC (mm)	GT (°C)	CATEGORY
TDK 1	1	100	70	Waxy
TDK 3	0	100	71	Waxy
TDK 5	0	100	70	Waxy
TDK 6	0	100	67	Waxy
TDK 7	0	100	70	Waxy
TDK 9	0	100	70	Waxy
PNG 1	0	100	71	Waxy
PNG 3	0	100	70	Waxy
PNG 6	0	100	71	Waxy
TSN 1	0	100	70	Waxy
NTN 1	0	100	71	Waxy
LNT 1	0	100	70	Waxy
TDK37-B-3-2-1	0	100	71	Waxy
TDK47-3-6-1-2-B	0	100	70	Waxy
TDK49-B-9-1-3-B	22	90	66	Non waxy
TDK25-B-14-3-B	0	100	70	Waxy
TDK33-9	32	100	75	Non waxy
TDK42-B-4-3	0	100	71	Waxy
TDK43-B-51-1-1-B	28	84	67	Non waxy

Table 4: Eating quality evaluation of waxy rice (%).

VARIETIES	CATEGORY			
	Soft Taste	Medium Taste	Hard Taste	Total
TDK 1	35	41	24	100
TDK 3	26	58	16	100
TDK 5	32	47	21	100
TDK 6	35	47	18	100
TDK 7	39	33	28	100
TDK 9	37	47	16	100
PNG 1	32	52	16	100
PNG 3	21	53	26	100
PNG 6	38	36	26	100
TSN 1	47	42	11	100
NTN 1	21	42	37	100
LNT 1	26	53	21	100
TDK37-B-3-2-1	0	63	37	100
TDK47-3-6-1-2-8	26	32	42	100
TDK25-B-14-3-B	28	56	16	100
TDK42-B-4-3	2	51	47	100
Max	47	63	47	
Min	0	32	11	
$MEAN \pm SD\bar{x}$	**28 ± 13**	**47 ± 9**	**25 ± 11**	

Table 5: Eating quality evaluation of non waxy rice (%).

VARIETIES	CATEGORY			
	Soft Taste	Medium Taste	Hard Taste	Total
TDK49-B-9-1-3-B	4	66	30	100
TDK33-9	4	43	52	100
TDK43-B-51-1-1-B	5	24	71	100
CR203	18	32	50	100
KDML105	86	14	0	100
Max	86	66	71	
Min	4	14	0	
MEAN $\pm$ SD$\bar{x}$	**23±25**	**36±20**	**41±27**	

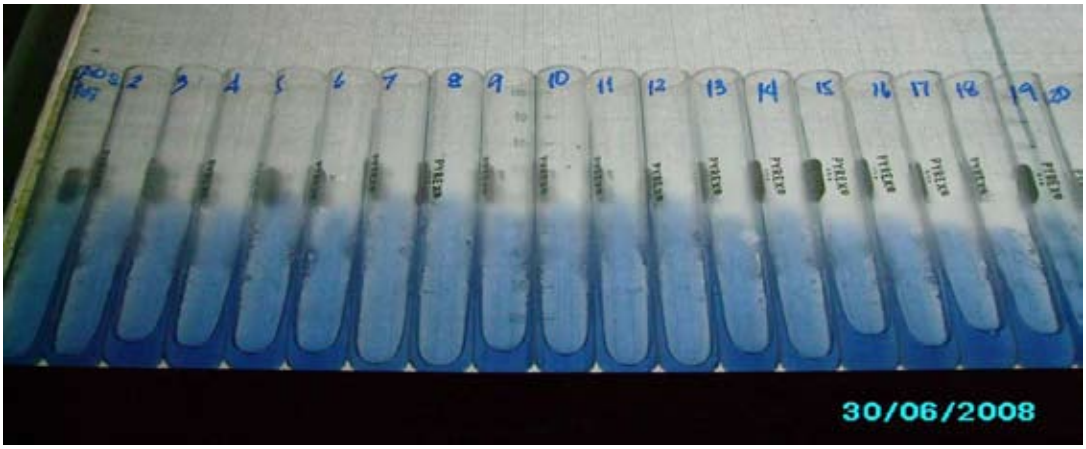

Figure 1 : Gel consistency analysis

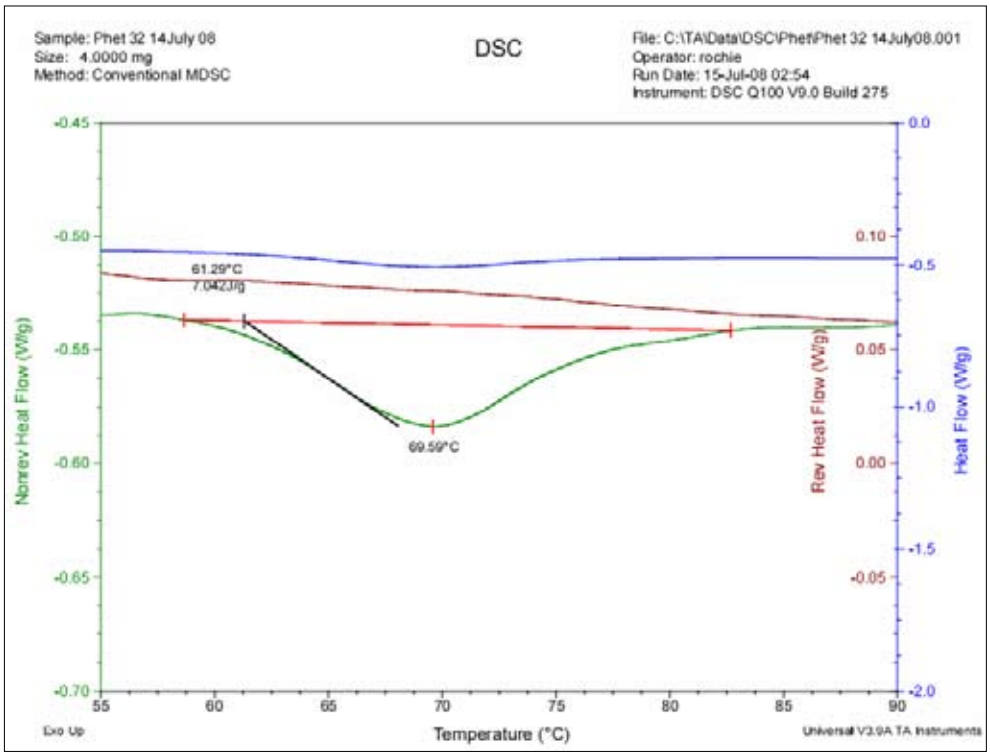

Figure 2 : Graphic of gelatinization temperature at 69.59°C

Figure 3 : Eating quality test by the researchers in RCCRC.

ການປະເມີນ ຄວາມຫຼາກຫຼາຍ ທາງດ້ານພັນທຸກຳ ຂອງ ແນວພັນເຂົ້າ ປັບປຸງ ຂອງ ລາວ ໂດຍການນຳໃຊ້ ເຕັກນິກໂມເລກຸນ

ເພັດມະນີແສງ ຊ້າງໄຊຍະສານ[1]; Fangming Xie[2] ແລະ Teresita H. Borromeo[3]

ບົດຄັດຫຍໍ້

ການປັບປຸງແນວພັນພືດ ເພື່ອໃຫ້ໄດ້ລັກຊະນະດີ ຕາມທີ່ຕ້ອງການນັ້ນ ແມ່ນມີຄວາມຈຳເປັນ ຈະຕ້ອງໄດ້ຄັດເລືອກ ເອົາພໍ່-ແມ່ພັນ ທີ່ມີຄວາມຫຼາກຫຼາຍທາງດ້ານພັນທຸກຳ ແລະ ທັງມີພື້ນຖານພັນທຸກຳ ທີ່ແຕກຕ່າງກັນດ້ວຍ. ຖ້າວ່າພໍ່-ແມ່ພັນ ມີພື້ນຖານທາງດ້ານພັນທຸກຳໃກ້ຄຽງກັນ ຈະເຮັດໃຫ້ການ ປັບປຸງແນວພັນພືດປະສົບຄວາມສຳເລັດໄດ້ຍາກ. ຈຸດປະສົງຂອງການຄົ້ນຄວ້າທົດລອງນີ້ ແມ່ນ (1) ເພື່ອສຶກສາເບິ່ງຄວາມແຕກຕ່າງທາງດ້ານພັນທຸກຳ ຂອງເຂົ້າແນວພັນປັບປຸງ ທີ່ໃຫ້ຜົນຜະລິດສູງ ຂອງ ລາວ ໂດຍການນຳໃຊ້ເຕັກນິກ ໂມເລກຸນ (SSRs markers) ແລະ (2) ເພື່ອກຳນົດເບິ່ງຄວາມຫຼາກຫຼາຍ ທາງດ້ານພັນທຸກຳ ຂອງເຂົ້າແນວພັນປັບປຸງ ຂອງລາວ ເພື່ອເປັນບ່ອນອີງ ໃນການຄັດເລືອກ ພໍ່-ແມ່ພັນ ສຳລັບການປັບປຸງພັນເຂົ້າຂອງລາວ ໃນອະນາຄົດ.

ໃນການສຶກສາຄັ້ງນີ້ ໄດ້ນຳໃຊ້ 60 SSRs markers ເພື່ອສຳຫຼວດ ຮູບຮ່າງທີ່ແຕກຕ່າງກັນ (polymorphism) ຂອງ 22 ແນວພັນເຂົ້າ. ຜົນການສຶກສາພົບວ່າ 45 SSRs markers ສາມາດຄົ້ນພົບ 109 ອັນລິດ (alleles). ຈຳນວນອັນລິນ ທີ່ພົບ ສັງເກດໄດ້ ແຕ່ 2 ຫາ 6 ອັນລິນ ແລະ ມີຄ່າສະເລ່ຍ 2.44 ອັນລິນ ຕໍ່ນຶ່ງໂລກາດ (locus). ໄລຍະຫ່າງ ທາງດ້ານພັນທຸກຳ ທີ່ນຳໃຊ້ເຕັກນິກຂອງ Jaccard ສາມາດກຳນົດ ຄວາມແຕກຕ່າງ ແລະ ຄວາມຄ້າຍຄືກັນ ລະຫວ່າງແນວພັນ. ການວິເຄາະການຈັດກຸ່ມ ໂດຍການນຳໃຊ້ໄລຍະຫ່າງທາງດ້ານ ໂມເລກຸນພັນທຸກຳ ລະຫວ່າງ 22 ແນວພັນ ໄດ້ຈັດກຸ່ມອອກເປັນ 7 ກຸ່ມ. ໃນນັ້ນ ເຂົ້າໜຽວລາວ ໄດ້ຖືກຈັດອອກເປັນ 4 ກຸ່ມ ເຊິ່ງໄດ້ສະແດງໃຫ້ເຫັນວ່າ ເຂົ້າໜຽວແນວ ພັນປັບປຸງຂອງລາວ ແມ່ນຍັງມີຄວາມຫຼາກຫຼາຍ ທາງດ້ານພັນທຸກຳ. ການວິເຄາະການຈັດກຸ່ມນີ້ ສາ ມາດກຳນົດໄດ້ເຖິງຄວາມສຳພັນ ທາງດ້ານພັນທຸກຳ ຂອງແນວພັນຕ່າງໆ. ແນວພັນ/ສາຍພັນ ທີ່ໄດ້ ພັດທະນາມາຈາກບັນພະບູລຸດດຽວກັນ ຈະຖືກຈັດເຂົ້າຢູ່ກຸ່ມດຽວກັນ. ຜົນການຄົ້ນຄວ້າໄດ້ສະແດງໃຫ້ ເຫັນວ່າ ເຕັກນິກໂມເລກຸນ ແມ່ນວິທີ ໜ້າເຊື່ອຖືທີ່ສຸດ ໃນການກຳນົດຄວາມສຳພັນ ແລະ ຄວາມຫຼາກ ຫຼາຍ ທາງດ້ານພັນທຸກຳ ລະຫວ່າງ ແນວພັນ.

Key words: *Genetic diversity, breeding materials, high yielding variety, molecular marker.*

[1]ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ, ສະຖາບັນ ຄົ້ນຄວ້າ ກະສິກຳ ແລະ ປ່າໄມ້ ແຫ່ງຊາດ.

[2]ສະຖາບັນຄົ້ນຄວ້າເຂົ້າສາກົນ, ປະເທດຟີລິບປິນ.

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Assessment of Genetic Diversity of Lao High Yielding Rice Cultivars Using SSR Markers

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Abstract

Breeding for good quality traits requires selection of parents with a wider genetic diversity. A narrow genetic base in the breeding materials limits genetic gains in breeding. The objective of this study were (i) to analyze Lao High Yielding Varieties (HYVs) for genetic variation using SSR markers and (ii) to determine the genetic diversity of Lao improved rice cultivars as the first step for proper identification and selection of suitable parents for future breeding program in Lao PDR.

In this study, 60 SSR primers were used to survey the polymorphisms among 22 cultivars. Results show that, 45 SSR polymorphic markers detected with a total of 109 alleles identified across cultivars. The number of alleles ranged from 2 to 6 with a mean of 2.44 per locus. Jaccard genetic distances can be used to estimate of genetic similarity and dissimilarity among the cultivars. Cluster analysis using molecular genetic distances among the 22 varieties generated 7 groups. The Lao glutinous varieties belong to 4 different groups, indicating diversity among the Lao HYVs. Cluster analysis was also able to detect pedigree relationships of the varieties. The varieties/lines that have shared common ancestor and sister lines based on the pedigree record were grouped together in one cluster. This results show that SSR is the most reliable tool in the determining relationships and genetic diversity between genotype.

Key worlds: Genetic diversity, breeding materials, high yielding variety, molecular marker.

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I. Introduction

Lao PDR is located between latitudes 14°10' and 20°10'N. The country has geographic area of 236,800 km^2 and is inhabited by about six million people. The collection of rice germplasm in the country began in 1995 and about 15,000 accessions of cultivated rice were collected. It has the second rice germplasm collection in the world which was conserved at IRRI's Rice Genebank and at Lao National Rice Genebank of which about 85% are waxy (Appa rao., *et al* 2000).

By 2005, the rice varietal improvement program had developed specific variety recommendation for the main lowland rice growing areas of Laos, the Mekong River Valley. There is a high level of farmer's acceptance and adoption of improved varieties developed and distributed during the 1990s. Adoption was more than 70% during wet season in the Mekong River Valley and 100% in irrigated condition in the dry season (Inthapanya *et al*., 2006).

Development of cultivars with high yielding and good grain qualities is an important objective of improvement programs today. However, rice improvement for these traits, using conventional breeding methods is difficult for plant breeders. Most of the traits that determine the quality are quantitative in nature. Polygenic inheritance and environmental interaction have compounded the difficulties in attempts at improving these complex traits through conventional breeding. Sufficient knowledge about genetic diversity in the genepool is a prerequisite to adopt an efficient and valuable breeding approach.

The recent development of DNA markers has provided new opportunities for the genetic improvement of rice breeding program. Molecular markers have been found to be powerful tools in the assessment of genetic variation. Microsatellite loci, also known as simple sequence repeats (SSRs) are among the most commonly used molecular markers. These markers can detect a significantly higher degree of polymorphism in rice (Ni *et al*. 2002, Okoshi *et al*. 2004). SSR marker can estimate genetic diversity between cultivars e.g. between parents of a genepool or between plants extracted from a population (Panaud et al. 1996, Akagi *et al*. 1997) or between populations. Olufowote *et al*. (1997) reported that microsatellites were more powerful for the identification of within cultivar variation.

The objective of this study were (i) to analyze Lao High Yielding Varieties (HYVs) for genetic variation using SSR markers and

(ii) to determine the genetic diversity of Lao improved rice cultivars as the first step for proper identification and selection of suitable parents for future breeding program in Lao PDR.

II. Matrials and Methods

Planting materials

A total of 22 varieties, three varieties were obtained from IRRI and 19 varieties were obtained from Rice and Cash Crop Research Center, Lao PDR (Table 1). All varieties were grown under favorable conditions at the IRRI screen-house for DNA extraction.

Genomic DNA extraction and SSR assay.

The standard management practices for raising rice seedling were followed to ensure healthy and disease free seedlings. DNA was extracted from leaves of 25 days old seedlings following the modified CTAB method (Murray and Thompson 1980). Molecular analysis was conducted at the Gene Array and Molecular Marker Application (GAMMA) laboratory at IRRI. Sixty SSR markers were randomly selected from the list of Cornell's rice microsatellite markers displayed at the Cornell University Rice Gene web site, http://www.gramene.org/microsat/ssr.html (Table 2).

The Polymerase Chain Reaction (PCR) was carried out in a final volume of 15 *µl*. The PCR reaction mixture contained 1.5 *µl* 10xTBE buffer; 1.5 *µl* dNTP, 0.75 *µl* each forward and reverse primers; 0.75 *µl* of *Taq* DNA polymerase; 2 *µl* of DNA template and 7.75 *µl* of ddH_2O to reach the final reaction volume of 15 *µl*. Reactions were overlaid with mineral oil. Amplification was carried out in PTC-100 thermocycle machine. The PCR programs consisted of the following steps: initial denaturation for 5 min at 94°C; followed by 35 cycles of 1 min denaturation at 94°C, 1 min annealing at 55°C, 2 min extension at 72°C; followed by a final extension of 5 min at 72°C and holding at 15°C until recovery. Amplification products were subjected to electrophoresis in 8 % polyacrylamide gels with 1X TBE buffer at 100 volts for 1.5 to 3 hours, depending on the size of rice microsatellite (RM) and PCR product. After electrophoresis, gels were stained with SYBR Safe TM for 30 minutes. DNA bands were visualized under UV light using the Gel Documentation System. The molecular weights of PCR products were estimated relative to a 1-kb ladder that served as the size standard.

Data analysis

The clear and unambiguous SSR markers were scored. Allelic bands were scored on the basis of the presence or absence

of the amplified products, when a product is present in a genotype it was designated as 1, and when absent, designated as 0. Genetic similarities were estimated from the matrix of binary data using Jaccard's coefficient in the NTSYS-pc Numerical Taxonomy and Multivariate Analysis System (Rohlf 2000). The standardized value of the Jaccard's coefficient ranged from 0 to 1, with 1 indicating a maximum of similarity and 0 indicating a maximum of dissimilarity. The similarity coefficients were used for cluster analysis of the rice cultivars utilizing the Unweighted Pair Group Method with Arithmetic Averages (UPGMA). The analysis and dendrogram construction were performed using the NTSYS-pc. Genetic distances were calculated using Jaccard's coefficient formula as:

$$GDj = 1 - \left(\frac{N(1,1)}{N(1,1) + N(1,0) + N(0,1)}\right)$$

Where:

N (1, 1) is the number of loci with both accessions having the bands

N (1, 0) is the number of loci with band present in the first accession and absent in the second accession.

N (0, 1) is the number of loci with band absent in the first accession and present in the second accession.

III. Results and Discusion

Polymorphism microsatellite marker

Table 3 summarizes the results obtained based on the analysis of the 22 rice cultivars using the polymorphic SSR loci. The number of alleles varied widely among these loci. A total of the 60 SSR markers distributed throughout the entire rice chromosomes were used to survey the polymorphisms among 22 cultivars. Among the 60 markers used in the analysis, 45 (75%) showed polymorphism. Two alleles were detected at thirty two loci, three alleles at 9 loci, four alleles at 3 loci and 6 alleles at one locus. Eight primers were monomorphic and 7 had faint or no amplifications. The 45 SSR polymorphic markers detected with a total of 109 alleles identified across cultivars. The number of alleles ranged from 2 to 6 with a mean of 2.44 per locus, which is within the range of 2 to 5.5 alleles per locus for various classes of microsatellites reported by Cho *et al* (2000) and 2.5 alleles per locus reported by Caldo (1996). Rare alleles can also be used to measure genetic diversity; the higher the number of rare alleles, the higher is the variability of the sample. The allele is considered to be rare when it is revealed in less than 5% of the genotype under analysis (Jain *et al* 2004). In this study, rare

alleles were only 3.66 % of the total alleles detected.

Genetic distances among cultivars.

Jaccard genetic distances of all possible pairs of the cultivars are presented in Table 4. The estimation of genetic similarity and dissimilarity among the cultivars ranged from 0.33 to 0.97. The genetic distance among the Lao cultivars ranged from 0.33 (TDK33-9 vs TDK6) to 0.97 (TDK6 vs TDK7), with an average of 0.53, while the IRRI cultivars ranged from 0.48 (IR58025B vs IR65) to 0.57 IR65 vs IR75589-31-27-8-33S), with an average of 0.52. This results show that Lao cultivars have more genetic divergence or more diversity compared to the IRRI cultivars. This is also indicates that the high yielding varieties (HYVs) from Laos are diverse.

Clustering of rice varieties.

The dendrogram based on the SSR markers used is presented in Figure 1. Based on the longest arm, the 22 cultivars used in the study formed 7 clusters, where IR58025B IR75589-31-27-8-33S and IR65 belong to the different clusters (group 3, 6 and 7, respectively). IR65 is a modern glutinous variety and can be different from Lao glutinous varieties and IR58025B is a maintainer line used for three-line hybrid rice. IR75589-31-27-8-33S is a line used for two-line hybrid rice and group with TDK33-9, none waxy rice from Laos. Interestingly, the Lao glutinous varieties used in this study belong to 4 different groups (groups 1, 2, 4 and 5). This results show that, there is divergence among Lao glutinous HYVs derived from the same national breeding program. Group 1 was comprised of 4 varieties (TDK1, TDK9, TDK47-3-6-1-2-B and TDK49-B-9-1-3-B) which clustered at similarity coefficient of 59%. Group 2 was the most diverse than the other group. This group comprised of 7 varieties (TDK5, TDK37-B-3-2-1,TDK25-B-14-3-B,TDK42-B-4-3, PNG1, TSN1 and PNG3). Group 4 contained of 2 varieties (TDK3 and TDK43-B-51-1-1-B). Group 5 was comprised of 5 varieties (TDK6, TDK7, PNG6, NTN1 and NTN1). The grouping in general conform with the pedigree data (Table 1), varieties and lines known to be genetically related through their pedigree record belong to the same group such as: TDK9 and TDK47-3-6-1-2-B were shared common ancestor to TDK1, there fore they belong to the same cluster (cluster 1). TDK5, TDK37-B-3-2-1 and TDK42-B-4-3 were shared common ancestor; therefore they belong to the same cluster (cluster 2). TDK3 is one of the parent of TDK43-B-51-1-1, so they were grouped in the same cluster (cluster 4). TDK6 and PNG6 were also group together, due to they

shared common ancestor. TDK7 and LNT1 are known as sister lines, therefore, they belong to same cluster (cluster 5). Results of this study also proved the efficiency of SSR in detecting genetic diversity in rice as report by several workers (Caldo 1996 and Xu *et al.* 2002).

IV. Conclusion and Recommendation

Information on genetic relationship and diversity among the parental lines are very important in identifying heterotic gene pools. Advancement in biotechnology made it possible to analyze diversity at the molecular level. This information can be used as a basic source for implementing the rice breeding program. In this study, 60 SSRs primers were used to survey the polymorphisms among 22 cultivars. Results show that, 45 SSRs polymorphic markers detected with a total of 109 alleles identified across cultivars. The number of alleles ranged from 2 to 6 with a mean of 2.44 per locus.

Jaccard genetic distances can be used to estimate of genetic similarity and dissimilarity among the cultivars. In this study, genetic distance among cultivars ranged from 0.33 to 0.97. This main that, Lao high yielding varieties have more genetic divergence or more diversity. There fore, genetic distance data can is useful to estimate genetic diversity of the parental lines which will be use for hybridization.

Cluster analysis using molecular genetic distances among the 22 cultivars generated in to 7 groups. The Lao glutinous varieties belong to 4 different groups, indicating diversity among the Lao varieties. Cluster analysis was also able to detect pedigree relationships of the cultivars. The varieties/lines that have shared common ancestor and sister lines based on the pedigree record were grouped together in one cluster. This results show that SSR is the most reliable tool in the determining relationships and genetic diversity between genotype. However, genetic distances of the parents can not be used a reliable indicator or predictor of heterosis for grain yield, due to the complexity of the trait (yield), because of the trait was controlled by polygene and easily affected by the environment.

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VII. Annexes

Table 1: Parental lines involved in the study

Varieties	Pedigree	Endosperm type	Country /source
IR58825B	-	Non Waxy	IRRI
IR65	BATATAIS/IR36//IR52	Waxy	IRRI
IR75589-31-27-8-33S	-	Non Waxy	IRRI
TDK 1	SPT77149/IR13423-10-2-3	Waxy	Laos
TDK 3	-	Waxy	Laos
TDK 5	RD10/B1014	Waxy	Laos
TDK 6	IR54081-CPA-3-B-1-3/IR41110-B-B-43 //SLK3-1-2-2	Waxy	Laos
TDK 7	IR63943-25-B-1/IR55810-UBN-1-1-2-1-1	Waxy	Laos
TDK 9	TDK1/RD6//RD6	Waxy	Laos
PNG 1	UBN6721-13-5-6/IR19660-73-4-2	Waxy	Laos
PNG 3	IR60290-CPA-1-2-1-1-3/IR57519-PMI 5-2 //IR57458-PMI 17-B-1-1	Waxy	Laos
PNG 6	IR49733-SRN-5-B-1-2/Malagkit SungSong //IR54081-CPA-3-B-1-3	Waxy	Laos
TSN 1	NSPT/IR21015-80-3-3-1-2	Waxy	Laos
NTN 1	NSPT/KKN7409-SRN-501-IR19431-72-2	Waxy	Laos
LNT 1	IR63943-25-B-1/IR55810-UBN-1-1-2-1	Waxy	Laos
TDK37-B-3-2-1	RD10/TDK1	Waxy	Laos
TDK47-3-6-1-2-B	RD23/TDK5//TDK1	Waxy	Laos
TDK49-B-9-1-3-B	RD10/PSBRC10	Non Waxy	Laos
TDK25-B-14-3-B	Makhing/IR57514-PMI-5-B-1-2	Waxy	Laos
TDK33-9	IR43070-UBN-501-2/IR57514-PMI-5-B-1-2	Non Waxy	Laos
TDK42-B-4-3	TDK1/IR65//TDK3	Waxy	Laos
TDK43-B-51-1-1-B	CR203/RD10//TDK3	Non Waxy	Laos

Table 2: SSR primers used in the study.

SSR MARKERS	CHROMOSOME LOCATION	SSR MARKERS	CHROMOSOME LOCATION	SSR MARKERS	CHROMOSOME LOCATION	SSR MARKERS	CHROMOSOME LOCATION
RM200	1	RM119	4	RM340	6	RM219	9
RM306	1	RM241	4	RM586	6	RM410	9
RM428	1	RM261	4	RM172	7	RM228	10
RM431	1	RM273	4	RM336	7	RM244	10
RM578	1	RM349	4	RM478	7	RM271	10
RM48	2	RM551	4	RM481	7	RM590	10
RM110	2	RM159	5	RM501	7	RM144	11
RM318	2	RM421	5	RM32	8	RM209	11
RM452	2	RM430	5	RM38	8	RM332	11
RM475	2	RM538	5	RM126	8	RM479	11
RM132	3	RM574	5	RM152	8	RM4	12
RM156	3	RM50	6	RM284	8	RM101	12
RM168	3	RM136	6	RM433	8	RM235	12
RM218	3	RM162	6	RM105	9	RM309	12
RM570	3	RM190	6	RM189	9	RM453	12

Table 3: Number of alleles detected by individual SSR markers and their chromosome location.

SSR MARKERS	CHROMOSOME LOCATION	No of ALLELES	RARE ALLELS	SSR MARKERS	CHROMOSOME LOCATION	No of ALLELS	RARE ALLELS
RM200	1	2	0	RM190	6	2	0
RM428	1	2	0	RM340	6	2	0
RM431	1	2	0	RM586	6	2	0
RM48	2	2	0	RM172	7	2	0
RM110	2	2	0	RM478	7	2	0
RM318	2	2	1	RM481	7	6	0
RM452	2	2	0	RM501	7	3	0
RM475	2	2	0	RM126	8	2	0
RM168	3	3	0	RM152	8	3	0
RM218	3	3	0	RM105	9	2	0
RM570	3	3	0	RM219	9	4	0
RM119	4	2	0	RM228	10	4	0
RM241	4	3	0	RM244	10	3	0
RM261	4	4	0	RM271	10	2	0
RM273	4	2	0	RM590	10	2	0
RM349	4	2	0	RM144	11	2	0
RM551	4	2	0	RM209	11	3	0
RM159	5	2	0	RM332	11	2	0
RM421	5	2	0	RM4	12	2	0
RM430	5	2	1	RM101	12	2	0
RM574	5	2	0	RM235	12	3	1
RM136	6	2	0	RM453	12	2	0
RM162	6	2	0				

Table 4: SSR primers used in the study.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
P2	0.58																				
P3	0.48	0.50																			
P4	0.50	0.41	0.43																		
P5	0.51	0.42	0.46	0.97																	
P6	0.70	0.49	0.49	0.50	0.51																
P7	0.54	0.61	0.62	0.49	0.51	0.54															
P8	0.56	0.44	0.49	0.56	0.58	0.51	0.60														
P9	0.47	0.44	0.49	0.89	0.86	0.45	0.51	0.55													
P10	0.65	0.55	0.55	0.59	0.60	0.57	0.73	0.66	0.58												
P11	0.44	0.41	0.49	0.83	0.80	0.42	0.47	0.51	0.93	0.54											
P12	0.46	0.41	0.47	0.86	0.83	0.44	0.51	0.56	0.93	0.59	0.93										
P13	0.58	0.55	0.67	0.42	0.43	0.57	0.66	0.51	0.43	0.58	0.44	0.44									
P14	0.58	0.51	0.55	0.47	0.46	0.60	0.52	0.48	0.46	0.58	0.47	0.49	0.55								
P15	0.58	0.54	0.57	0.47	0.48	0.60	0.57	0.52	0.46	0.60	0.43	0.45	0.55	0.86							
P16	0.55	0.55	0.65	0.46	0.47	0.50	0.71	0.58	0.45	0.60	0.48	0.50	0.70	0.58	0.58						
P17	0.42	0.41	0.40	0.33	0.34	0.42	0.50	0.47	0.34	0.41	0.35	0.35	0.48	0.46	0.51	0.53					
P18	0.56	0.58	0.60	0.43	0.44	0.46	0.64	0.50	0.44	0.54	0.47	0.46	0.72	0.54	0.54	0.89	0.51				
P19	0.38	0.58	0.45	0.38	0.39	0.39	0.45	0.45	0.39	0.50	0.42	0.40	0.52	0.42	0.44	0.52	0.48	0.51			
P20	0.51	0.43	0.50	0.46	0.50	0.50	0.57	0.50	0.46	0.65	0.45	0.47	0.53	0.51	0.49	0.51	0.51	0.51	0.46		
P21	0.45	0.38	0.46	0.52	0.49	0.45	0.49	0.54	0.51	0.49	0.55	0.55	0.45	0.52	0.50	0.52	0.45	0.48	0.41	0.48	
P22	0.45	0.39	0.38	0.40	0.41	0.43	0.46	0.56	0.40	0.43	0.41	0.42	0.47	0.40	0.40	0.49	0.69	0.46	0.49	0.52	0.57

P1: TDK1; P2: TDK3; P3:TDK5; P4:TDK6; P5:TDK7; P6:TDK9; P7:PNG1; P8:PNG3; P9:PNG6; P10:TSN1; P11:NTN1; P12:LNT1; P13:TDK37-B-3-2-1; P14: TDK37-3-6-1-2; P15:TDK49-B-9-1-3-B; P16:TDK25-B-14-3-B; P17:TDK33-9; P18:TDK42-B-4-1; P19:TDK43-B-51-1-1-B; P20:IR58025B; P21:IR65; P22:IR75589-31-27-8-33S.

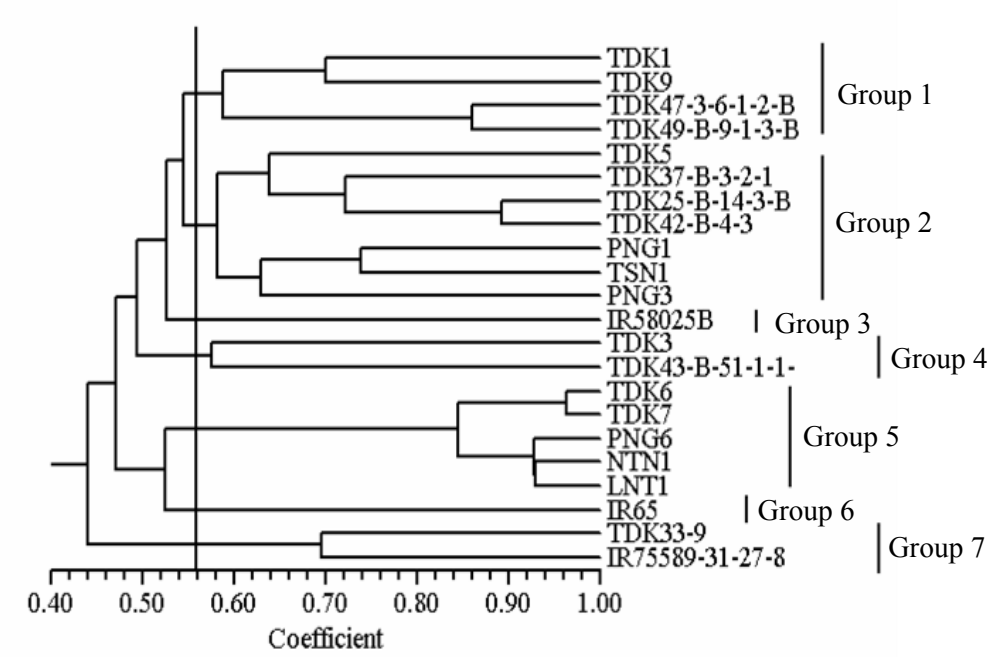

Figure 1 : Dendrogram showing the genetic similarities of 22 parental lines of the hybrids using SSR

Figure 2 : TDK11 variety

ສຶກສາຮູບແບບການລ້ຽງໝູພັນພື້ນເມືອງໃສ່ຂຸມ ຢູ່ ທາງພາກເໜືອ ຂອງ ສປປ ລາວ

ໂສພາ ຊາຍຜາ[1] ຄະນະວົງ ລັດຕະນະວົງສິນ[1] ສຸຄັນທອນ ຂຸນສະມາທອງ[1]
ວຽງຄຳ ວົງຊົມພູ[1]

ບົດຄັດຫຍໍ້

ການທົດລອງໄດ້ນຳໃຊ້ໝູເພດແມ່ພັນພື້ນເມືອງລາວ ຈຳນວນ 60 ໂຕ ອາຍຸ 3-4 ເດືອນ ນ້ຳໜັກໂດຍສະເລ່ຍ 15 ກິໂລກຼາມ. ສັດຖືກແຈກຍາຍ ເຂົ້າໃນຮູບແບບການທົດລອງ ແບບ RCBD. ມີ ສອງຈຸການທົດລອງ ຄື: ຈຸທີ 1: ໃຫ້ກິນອາຫານຂອງທ້ອງຖິ່ນ ແລະ ຈຸທີ 2: ໃຫ້ກິນອາຫານຂອງທ້ອງຖິ່ນ ແຕ່ໃຫ້ ສະໄຕໂລ (CIAT 104) ເປັນອາຫານເສີມ ໂດຍນຳໃຊ້ຮຳເປັນອາຫານພື້ນຖານ. ໄລຍະການ ທົດລອງ 150 ວັນ. ສະຖານທີ່ທົດລອງ ຢູ່ ເມືອງນາໝໍ້ ແຂວງອຸດົມໄຊ ແລະ ເມືອງໂພນໄຊ ແຂວງຫຼວງ ພະບາງ. ຈຸດປະສົງ ເພື່ອຕອບສະໜອງຝຸ່ນຄອກໃສ່ໄມ້ໃຫ້ໝາກ, ພືດຜັກ ແລະ ສວນຢາງພາລາ ຂອງ ຊາວກະສິກອນ ເຂດພູດອຍ, ເພື່ອສຶກສາຮູບແບບ ການຜະລິດກະສິກຳ ແບບປະສົມປະສານຮ່ວມກັບ ຊາວກະສິກອນ ແລະ ເພື່ອສ້າງລາຍຮັບດ້ວຍການລ້ຽງໝູ ແກ່ຊາວກະສິກອນ ເຂດພູດອຍ. ຜົນຈາກການ ວິເຄາະຂໍ້ມູນ ທີ່ໄດ້ຈາກການທົດລອງຄັ້ງນີ້ ເຫັນວ່າ ບໍ່ມີຄວາມແຕກຕ່າງກັນຫຼາຍ ຂອງການເພີ້ມນ້ຳໜັກ ຂອງ ສັດ (ADG); ແຕ່ວ່າ ໃນຈຸທີ 2 ດີກວ່າ ຈຸທີ 1 ຂອງ ທັງສອງເມືອງ ໂດຍສະເພາະ ເຫັນຈະແຈ້ງທີ່ສຸດ ແມ່ນຢູ່ເມືອງໂພນໄຊ ຄື: 339 ກຼາມ/ໂຕ/ວັນ, ສ່ວນຢູ່ເມືອງນາໝໍ້ ມີພຽງ 230 ກຼາມ/ໂຕ/ວັນ. ອັດຕາການ ແລກປ່ຽນອາຫານເປັນຊີ້ນ 11.3% ແລະ 13.7%; ອັດຕາການຕາຍ ຂອງສັດ 0% ແລະ 13% ຕາມລຳດັບ.

ຄຳສັບຫຼັກ: *ໝູພັນພື້ນເມືອງລາວ, ຝຸ່ນຄອກ, ຖົ່ວສະໄຕໂລ, ການເພີ່ມນ້ຳໜັກ, ອັດການແລກປ່ຽນອາຫານ, ອັດຕາການຕາຍຂອງສັດ.*

[1]ສູນຄົ້ນຄວ້າການລ້ຽງສັດ, ສະຖາບັນ ຄົ້ນຄວ້າ ກະສິກຳ ແລະ ປ່າໄມ້ ແຫ່ງຊາດ, ກະຊວງ ກະສິກຳ ແລະ ປ່າໄມ້.

Study on local pigs raising for compost utilization in upland area of Laos

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Abstract

Sixty female of local pigs and weighing on average 15 kg, , were used in RCBD arrangement to study the effect of the Stylo 184 in growth performance and composts production. The main feed used rice brand (RB) plus maize as basal in diet. The pigs were housed in groups with five pigs per one group, and allotted at random to the two treatments. The feeding trial lasted for 05 months (150 days). There was non significant on live weight gain (ADG) and feed conversion ratio (FCR) between treatment .But the supplement diet was improved growth performance and FCR . There appear to be advantages in terms of local pig growth and feed conversion with addlibitum of Stylo 184 in fresh form as the main protein source base on rice bran or maize as basal in diet.

Key words: *local pigs, composts, stylo 184,live weight gain, feed conversion mortality rate.*

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I. ພາກສະເໜີ

ອີງຕາມຂໍ້ມູນທີ່ທີມງານໄດ້ລົງສຳຫຼວດໃນ ລະຫວ່າງ ເດືອນມັງກອນ ປີ 2007 ຊຶ່ງຄອບຄົວ ກຸ່ມຊາວກະສິກອນ ຜູ້ທີ່ປູກໄມ້ກິນໝາກ ແລະ ສວນຢາງພາລາ ນອນໃນໂຄງການ ຄົ້ນຄວ້າ ເຂດພູດອຍ ແລະ ພັດທະນາຄວາມສາມາດ ຢູ່ ເມືອງໂພນໄຊ ແຂວງຫຼວງພະບາງ ແລະ ເມືອງ ນາໝໍ້ ແຂວງອຸດົມໄຊ ໄດ້ໃຫ້ຄຳເຫັນວ່າ: ຕົ້ນໄມ້ ໃຫ້ໝາກ ແລະ ຢາງພາລາ ເຂົາເຈົ້າຂາດຝຸ່ນ ຈຶ່ງ ເຮັດໃຫ້ພືດເຕີບໂຕຊ້າ. ດັ່ງນັ້ນ, ທາງຄະນະຮັບ ຜິດຊອບໂຄງການ ຈຶ່ງໄດ້ແນະນຳໃຫ້ ທີມງານ ວິຊາການ ຄົ້ນຄວ້າຊອກຫາວິທີແກ້ໄຂ ບັນຫາ ດັ່ງກ່າວ ໂດຍໃຫ້ກຸ່ມຊາວກະສິກອນ ລ້ຽງໝູລາດ ໃສ່ຂຸມ ເພື່ອຜະລິດຝຸ່ນຄອກຊີວະພາບ ໃສ່ໄມ້ໃຫ້ ໝາກ ຂອງເຂົາເຈົ້າເອງ ຊຶ່ງສາມາດຊ່ວຍຫຼຸດຜ່ອນ ຕົ້ນທຶນຊື້ປຸ໋ຍຢູ່ຕາມທ້ອງຕະຫຼາດ. ນອກຈາກຈະ ໄດ້ຝຸ່ນປັບປຸງດິນແລ້ວ ເຂົາເຈົ້າ ຍັງມີກຳໄລຈຳ ນວນນຶ່ງ ຈາກການຂາຍໝູນຳອີກດ້ວຍ. ການຄົ້ນ ຄວ້າທົດລອງໃນຄັ້ງນີ້ ກໍ່ເພື່ອແກ້ໄຂບັນຫາຂາດ ຝຸ່ນ ໃສ່ຕົ້ນໄມ້ກິນໝາກ ກໍຄືພືດຜັກອື່ນໆ ພ້ອມນີ້ ກໍນຳເອົາຄວາມຮູ້ທາງດ້ານເຕັກນິກວິຊາການລ້ຽ ງສັດແບບໃໝ ່ ລົງຈັດຕັ້ງປະຕິບັດຮ່ວມກັບຊາວກ ະສິກອນ ເຊັ່ນ: ວິທີການລ້ຽງໝູແບບຂັງ ໃນຄອກ ໂດຍມີການໃຫ້ຖົ່ວສະໄຕໂລ ເປັນອາຫານເສີມ, ເຕັກນິກການກຸ່ມຂຸມ ເພື່ອລ້ຽງໝູ ຜະລິດຝຸ່ນ ແລະ ວິທີການຜະລິດ ນ້ຳສະກັດ ຊີວະພາບ (EM = effective micro-organism) ເພື່ອໃຊ້ທົດພື້ນ ຄອກສັດ ແລະ ອື່ນໆ.

II. ທົບທວນເອກະສານ

ພັກ ແລະ ລັດຖະບານ ຂອງພວກເຮົາ ມີ ນະໂຍບາຍປະຢັດມັດທະຍັດ ຜະລິດກຸ້ມຕົນເອງ ເພື່ອຫຼຸດຜ່ອນການນຳເຂົ້າສິນຄ້າ ຈາກຕ່າງປະ ເທດ ທຸກຮູບແບບ, ການນຳໃຊ້ນ້ຳສະກັດ ຊີວະ ພາບ (EM=effectivemicro-organism) ເຂົ້າໃນ ວຽກງານປູກຝັງ ແລະ ລ້ຽງສັດ ຮັກສາສິ່ງແວດ ລ້ອມ ຊຶ່ງແມ່ນວິທີການນຶ່ງປະກອບສ່ວນເຂົ້າໃນນ ະໂຍບາຍດັ່ງກ່າວ. ນ້ຳສະກັດຊີວະພາບ ສາມາດ ຜະລິດເອງໄດ້ໂດຍການນຳໃຊ້ວັດຖຸໃນຄົວເຮືອນ ຫຼື ເສດເຫຼືອກະສິກຳ ມາປຸງແຕ່ງເພື່ອນຳໃຊ້ເຂົ້າ ໃນການກຳຈັດກິ່ນເໝັນ ຂອງຄອກສັດ, ເພີ້ມຜົນ ຜະລິດ, ຫຼຸດຜ່ອນການລະບາດສັດຕູພືດ, ຊ່ວຍ ປັບປຸງດິນ, ຕົ້ນທຶນຕ່ຳ ແລະ ອື່ນໆ (ປຶ້ມຄູ່ມືນ້ຳສະ ກັດຊີວະພາບ ເພື່ອການປູກຝັງ-ລ້ຽງສັດ ແລະ ສິ່ງແວດລ້ອມ, ພະແນກ ກະສິກຳ ແລະ ປ່າໄມ້ ນະ ຄອນຫຼວງວຽງຈັນ 2004). ຜົນການຄົ້ນຄວ້າ ທົດ ລອງ ຂອງ ທ່ານ ພອນປະເສີດ ເພັງສະຫວັນ ໃນປີ 1997 ໄດ້ໃຫ້ຮູ້ວ່າ ພືດຕະກຸນຖົ່ວ STYLO 184 ສາມາດປູກ ແລະ ປັບຕົວໄດ້ດີ ໃນຂອບເຂດ ທົ່ວປະເທດ ຊຶ່ງບັນຈຸທາດຊີ້ນ ແຕ່ 20 ຫາ 25% ສາມາດນຳໄປລ້ຽງສັດ ທຸກປະເພດ ແລະ ບໍ່ມີ ຜົນເສຍຕໍ່ສຸຂະພາບສັດ ແຕ່ຢ່າງໃດເລີຍ. ການ ລ້ຽງໝູຕາມແບບທຳມະຊາດ ຂອງເກົາຫຼີ ນອກ ຈາກຜູ້ລ້ຽງມີກຳໄລດີ ເນື່ອງຈາກສາມາດຫຼຸດຜ່ອນ ຕົ້ນທຶນອາຫານໄດ້ 70% ແລ້ວ ຍັງສາມາດຫຼຸດ ຜ່ອນແຮງງານ ໃນການລ້ຽງສັດ, ການອະນາໄມ ຄອກ, ຄອກໝູບໍ່ມີກິ່ນເໝັນ ບໍ່ເປື້ອນ ຈົນສາ ມາດ ຮັບປະທານອາຫານ ຢູ່ພາຍໃນຄອກໝູໄດ້ (Chokchai, 2004).

III. ຈຸດປະສົງ

1. ເພື່ອຕອບສະໜອງຝຸ່ນຄອກໃສ່ໄມ້ໃຫ້ໝາກ, ພືດຜັກ ແລະ ສວນຢາງພາລາ ຂອງຊາວກະສິກອນ ເຂດພູດອຍ.
2. ເພື່ອສຶກສາຮູບແບບການຜະລິດກະສິກຳ ແບບປະສົມປະສານຮ່ວມກັບຊາວກະສິກອນ ເຂດພູດອຍ.
3. ເພື່ອສ້າງລາຍຮັບດ້ວຍການລ້ຽງໝູແກ່ ຊາວກະສິກອນ ເຂດພູດອຍ.

IV. ອຸປະກອນ ແລະ ວິທີການ

1. ສະຖານທີ່, ໝູມອາກາດ ແລະ ເວລາ ຂອງ ການທົດລອງ

ການທົດລອງຄັ້ງນີ້ ໄດ້ດຳເນີນຮ່ວມກັບຊາວກະສິກອນ ໃນ 6 ບ້ານ ຄື: ບ້ານທ່າໂພໃຕ້, ທ່າໂພເໜືອ ແລະ ບ້ານນ້ຳບໍ່ ເມືອງໂພນໄຊ ແຂວງຫຼວງພະບາງ ແລະ ບ້ານນາໝໍ້ເໜືອ, ນາໝໍ້ໃຕ້ ແລະ ບ້ານປາງທອງ ເມືອງນາໝໍ້ ແຂວງອຸດົມໄຊ. ປະຕິບັດ 5 ເດືອນ ຊຶ່ງເລີ້ມແຕ່ ເດືອນມີຖຸນາ ຫາ ເດືອນພະຈິກ ປີ 2007. ສະພາບພື້ນທີ່ ຢູ່ໃນ 2 ເມືອງ ມີຄວາມແຕກຕ່າງກັນ ອຸນຫະພູມຕ່ຳສຸດ ມີການປ່ຽນແປງ ແຕ່ 0 ຫາ 17 ອົງສາ ແລະ ອຸນຫະພູມຕ່ຳກວ່າ 8 ອົງສາ ເກີດຂຶ້ນໃນຊ່ວງ ເດືອນ 11 ຫາ ເດືອນ 3; ສ່ວນໃຫຍ່ແມ່ນເກີດຂຶ້ນ ໃນພາກເໜືອ ແລະ ເຂດທີ່ມີສະພາບພູມສັນຖານ ສູງຊັນ. ອຸນຫະພູມສູງສຸດ ໄດ້ມີການປ່ຽນແປງແຕ່ 13 ຫາ 36 ອົງສາ ໃນເດືອນ 4 ແລະ ອຸນຫະພູມ ສະເລ່ຍ ມີການປ່ຽນແປງ ແຕ່ 6.9 ຫາ 27.7 ອົງສາ. ກະຈາຍປະລິມານນ້ຳຝົນ ສະເລ່ຍ ປີ ສູງສຸດ 3,600 ມມ ແລະ ຕ່ຳສຸດ 1,200 ມມ. ໄລຍະເວລາ ການທົດລອງ 150 ວັນ ເລີ້ມແຕ່ ເດືອນ 6-11 / 2007.

2. ອຸປະກອນ

ອຸປະກອນທີ່ນຳໃຊ້ເຂົ້າໃນການສຶກສາ ມີ: ຄອກ ໝູຂະໜາດ 3 ມ x 5 ມ, ແນວພັນໝູລາດ ຈຳນວນ 5 ໂຕ ຕໍ່ຄອບຄົວ, ແກ່ນຫຍ້າຖົ່ວສະຕາຍໂລ 184 ຈຳນວນ 2 ກິໂລ ຕໍ່ຄອບຄົວ ແລະ ນ້ຳສະກັດ ຊີວະພາບ (EM = effective micro-organism) ຈຳນວນ 2 ລິດ ຕໍ່ຄອບຄົວ. ຄຸນສົມບັດ ແລະ ວິທີການນຳໃຊ້ ຈຸລິນຊີ ທີ່ເປັນປະໂຫຍດ EM ຂອງໂຄງການອີເອັມ ພະແນກ ກະສິກຳ ແລະ ປ່າໄມ້ ນະຄອນຫຼວງວຽງຈັນ ແລະ ອົງການ ກະສິກຳ ທຳມະຊາດ ອາຊີປາຊີຟິກ (APNAN = Asian Pacific Natural Agriculture Network) ມີດັ່ງນີ້:

1. ໃຊ້ທົດພືດຜັກ, ນາເຂົ້າ, ໄມ້ກົ້ນໝາກ ອາທິດ ລະ 1-2 ຄັ້ງ ໃນອັດຕາ 1 ຝາ ຕໍ່ນ້ຳ 1 ບົວ.
2. ປະສົມກັບນ້ຳໃນອັດຕາ ນ້ຳອີເອັມ ເຄິ່ງຝາ ປະສົມນ້ຳບຶ່ງບົວ ໃຫ້ສັດກິນ ສັດຈະແຂງແຮງ ອາຈົມບໍ່ມີກິ່ນເໝັນ.
3. ໃຊ້ລ້າງຄອກໝູ ເພື່ອດັບກິ່ນເໝັນ
4. ກຳຈັດແກັດ ແລະ ດັບກິ່ນເໝັນຈາກມູນສັດ
5. ກຳຈັດໜອນ ແລະ ແມງວັນ
6. ໃສ່ໜອງປາ ປັບປຸງຄຸນນະພາບນ້ຳໃຫ້ດີຂຶ້ນ

3. ວິທີການ

ກ. ດ້ານການຈັດຕັ້ງ: ການຄົ້ນຄວ້າທົດລອງໄດ້ຈັດ ຕັ້ງປະຕິບັດ ໃນເດືອນ 05\11\2007. ໂດຍໄດ້ປະ ສານສົມທົບກັບພະນັກງານວິຊາການຂອງສູນ ພາກເໜືອ ແລະ ຜູ້ປະສານງານໂຄງການ ປະຈຳ ພາກສະໜາມ ຂອງ ສອງເມືອງຈຸດສຸມ.

ຂ. ເງື່ອນໄຂຜູ້ຈະເຂົ້າຮ່ວມໂຄງການ: ທາງທີມງານໄດ້ລົງສຳຫຼວດເອົາລາຍຊື່ຊາວກະສິກອນ ຜູ້ສະມັກເຂົ້າຮ່ວມກິດຈະກຳ ໂດຍອີງ ຕາມຫຼັກການ ຄື: ຜູ້ກ່ຽວຈະຕ້ອງມີສວນໄມ້ໃຫ້ໝາກ ຫຼື ສວນຢາງພາລາ, ຫຼື ສວນພືດຜັກ, ຫຼື ນາເຂົ້າ, ມີແຮງງານລ້ຽງສັດ, ມີເນື້ອທີ່ປູກພືດສະໄຕໂລ, ຕ້ອງເປັນຄົນດຸໝັ່ນ ເອົາໃຈໃສ່ທຳການຜະລິດ ກະສິກຳ ແທ້ຈິງ. ໃນນັ້ນ ມີຈຳນວນຄອບຄົວທີ່ເຂົ້າຮ່ວມ ເຮັດການຄົ້ນຄວ້າທົດລອງ ທັງໝົດ 12 ຄອບຄົວ ໃນ 6 ບ້ານ, ຈຳນວນໄດ້ທົດລອງ ທັງໝົດມີ 60 ໂຕ.

ຕາຕະລາງ 1: ລາຍຊື່ຊາວກະສິກອນ ຜູ້ເຂົ້າຮ່ວມກິດຈະກຳ

ລ/ດ	ລາຍຊື່ຊາວກະສິກອນ	ລາຍຊື່ບ້ານ	ຈຳນວນສັດທົດລອງ
1	ຄຳຜຸຍ	ນ້ຳບໍ່	5 ໂຕ
2	ວິເສດ	ນ້ຳບໍ່	5 ໂຕ
3	ທອງພັດ	ທ່າໂພໃຕ້	5 ໂຕ
4	ຄຳສິງ	ທ່າໂພໃຕ້	5 ໂຕ
5	ຊຍງພັດ	ທ່າໂພເໜືອ	5 ໂຕ
6	ຊຸງຜຸຍ	ທ່າໂພເໜືອ	5 ໂຕ
7	ທອງໄຫລ	ນາໝໍ້ເໜືອ	5 ໂຕ
8	ເຈືອທອມ	ນາໝໍ້ເໜືອ	5 ໂຕ
9	ສອນຈັນ	ນາໝໍ້ໃຕ້	5 ໂຕ
10	ເຈືອເມືງ	ນາໝໍ້ໃຕ້	5 ໂຕ
11	ເຢຍລີມົວ	ປາງທອງ	5 ໂຕ
12	ວາຢີເລົ່າ	ປາງທອງ	5 ໂຕ

ຄ. ດ້ານອາຫານສັດ: ອາຫານພື້ນຖານທີ່ນຳໃຊ້ໃນການລ້ຽງໝູ ແມ່ນອາຫານພື້ນບ້ານ (ຮຳ, ສາລີ) ສ່ວນອາຫານເສີມ ແມ່ນບອນ ແລະ ຖົ່ວສະໄຕໂລ. ເນື້ອທີ່ປູກຫຍ້າສະໄຕໂລ ແມ່ນ 2 ໄລ່ ຕໍ່ຄອບຄົວ, ສ່ວນໃບບອນ ແມ່ນມີຢູ່ຕາມປ່າ ທຳມະຊາດ, ການໃຫ້ອາຫານ ແມ່ນ ສອງ ຄາບ ຕໍ່ວັນ ເຊົ້າ ແລະ ແລງ ໃຫ້ກິນຕາມໃຈ.

ງ. ດ້ານສັດທົດລອງ: ຄັດເລືອກເອົາໝູລຸ້ນເພດແມ່ພັນພື້ນເມືອງ ທີ່ມີນ້ຳໜັກແຕ່ 15-20 ກລ ອາຍຸ ປະມານ 3-4 ເດືອນ ຊຶ່ງແມ່ນພະນັກງານ ວິຊາການ ປະຈຳພາກສະໜາມ ເປັນຜູ້ໄປຊື້ຢູ່ຕາມບໍລິເວນໄກ້ຄຽງກັບບ່ອນທົດລອງ. ສັດທຸກຕົວຕ້ອງໄດ້ຮັບການສັກຢາປ້ອງກັນພະຍາດອະຫິວາໝູ ແລະ ຂ້າແມ່ທ້ອງດ້ວຍຢາໄອໂວເມັກ ແລະ ໃຊ້ເວ

ລາປັບຕົວ ເຂົ້າກັບສະພາບແວດລ້ອມ 3 ອາທິດ ແລ້ວຈຶ່ງເລີ້ມລ້ຽງທົດລອງ ຢູ່ໃນຄອກ.

ຈ. ລະບົບການລ້ຽງ: ແມ່ນລ້ຽງແບບຂັງ ຢູ່ຄອກ ຂະໜາດ 3 ແມັດ x 5 ແມັດ . ອັດຕາປ່ອຍສັດ 5 ໂຕ ຕໍ່ 1 ຄອກ.

ສ. ວິທີການກຽມເຮັດພື້ນຄອກ: ຂຸດຂຸມເລິກ 90 ຊຕມ ແລະ ແບ່ງລວງເລິກຂອງຂຸມເປັນ 3 ຊັ້ນ (30 ຊຕມ/ຊັ້ນ) ແຕ່ລະຊັ້ນຖົມດ້ວຍແກບດິນຊັ້ນໜ້າ, ເກືອ ແລະ ຫົດດ້ວຍນ້ຳສະກັດຊີວະພາບ ອີເອັມ, ຖົມແກບຈົນເຕັມຂຸມ. ການຫົດພື້ນຄອກດ້ວຍນ້ຳ ສະກັດ ອີເອັມ, ຕ້ອງປະຕິບັດທຸກໆອາທິດ ໃນໄລ ຍະເວລາການທົດລອງ.

ຊ. ການອອກແບບການທົດລອງ: **ໄດ້**ນຳໃຊ້ຮູບ ແບບ RCBD ປະກອບມີ ສອງ ຈຸທົດລອງ ຄື:

ຈຸທີ 1 = ຮຳ + ບອນ (ຕົ້ມ)
ຈຸທີ 2 = ຮຳ + ບອນ (ຕົ້ມ) + ຖົ່ວສະໄຕໂລ

ການຄົ້ນຄວ້າທົດລອງຄັ້ງນີ້ ໄດ້ຈັດຕັ້ງປະ ຕິບັດຮ່ວມກັບຊາວກະສິກອນ ຢູ່ 2 ເມືອງ, ມີ 2 ຈຸທົດລອງ ຢູ່ໃນ 6 ບ້ານ ແຕ່ລະບ້ານ ປະກອບ ມີ 2 ຄອບຄົວ, ລວມທັງໝົດ ມີ 12 ຄອບຄົວ ແຕ່ລະຄອບຄົວ ມີສັດທົດລອງ 5 ໂຕ, ລວມທັງ ໝົດ ມີ 60 ໂຕ.

ຕາຕະລາງ 2: ການທົດລອງ ຢູ່ 2 ເມືອງ

ຈຸທົດລອງ	ເມືອງໂພນໄຊ						ເມືອງນາໝໍ້					
	ນ້ຳບໍ່ (BL1)		ທ່າໂພໃຕ້ (BL2)		ທ່າໂພເໜືອ (BL3)		ນາໝໍ້ເໜືອ (BL1)		ນາໝໍ້ໃຕ້ (BL2)		ປາງທອງ (BL3)	
	1	2	3	4	5	6	1	2	3	4	5	6
ຈຸທີ 1	5	0	5	0	5	0	5	0	5	0	5	0
ຈທີ 2	0	5	0	5	0	5	0	5	0	5	0	5

V. ວິທີການເກັບກຳຂໍ້ມູນ

ມີປຶ້ມໃຫ້ວິຊາການເມືອງ ແລະ ຊາວກະ ສິກອນ ບັນທຶກປະລິມານອາຫານທີ່ໃຫ້, ການນຳ ໃຊ້ຢາ ແລະ ສຸກຂະພາບຂອງສັດ, ພະນັກງານ ເມືອງ ແລະ ແຂວງ ລົງຕິດຕາມວຽກພາກສະໜາມ ປົກກະຕິ, ພະນັກງານ ຈາກໂຄງການຍ່ອຍ ລົງ ກວດກາປະເມີນຜົນ 3 ເດືອນ/ຄັ້ງ ແລະ ຂຽນບົດ ລາຍງານ.

ການເກັບກຳຂໍ້ມູນ

1. ການຈະເລີນເຕີບໂຕຂອງໝູ: ຊັ່ງນ້ຳໜັກສັດ ກ່ອນເລີ້ມຕົ້ນການທົດລອງ ຫຼັງຈາກນັ້ນ ແມ່ນຊັ່ງ ທຸກໆເດືອນ ໂດຍກຳນົດວັນທີ ໃຫ້ຖືກຕ້ອງຄັກແນ່. ວິທີການຊັ່ງນ້ຳໜັກສັດ ແມ່ນຕ້ອງເຮັດໃນຕອນ ເຊົ້າ ກ່ອນໃຫ້ອາຫານ.

2. ເກັບເອົາຕົວຢ່າງອາຫານ ເພື່ອວິໃຈຫາທາດ DM, CP ແລະ ຊັ່ງນ້ຳໜັກຝຸ່ນ, ເກັບຕົວຢ່າງຝຸ່ນ ຄອກເພື່ອວິໃຈຫາທາດ NPK.

ພາຍຫຼັງ ຊາວກະສິກອນຂາຍສັດ ອອກສູ່ຕະຫຼາດ (ໄລຍະເວລາລ້ຽງ 5 ເດືອນ).

3. ຄິດໄລ່ອັດຕາການແລກປ່ຽນອາຫານເປັນຊີ້ນ

4. ອັດຕາການຕາຍຂອງສັດ

5. ໄລ່ລ່ຽງເສດຖະກິດ

VI. ການເກັບຂໍ້ມູນ

ແມ່ນການເກັບກຳຂໍ້ມູນເສດຖະກິດ ດ້ວຍວິທີການ ແລະ ຮູບແບບການສົນທະນາ ກັບ ຊາວກະສິກອນ ທີ່ເຂົ້າຮ່ວມໂຄງການ, ການນຳ ໃຊ້ແຮງງານ ຂອງຊາວກະສິກອນ, ໃນນັ້ນ ປະ ກອບມີ ວັດຖຸອຸປະກອນທີ່ນຳໃຊ້ ເຂົ້າໃນການທົດ ລອງ ເຊັ່ນ: ແນວພັນສັດ, ແນວພັນຫຍ້າ, ອາ ຫານ, ແຮງງານ ແລະ ອື່ນໆ. ເພື່ອຄຳນວນຫາ ລາຍຮັບ, ລາຍຈ່າຍ ແລະ ຄ່າຜິດຕ່ຽງ ເພື່ອຈະນຳ ມາປຽບທຽບ ແຕ່ລະຈຸທົດລອງ.

VII. ການວິເຄາະຂໍ້ມູນ

ຂໍ້ມູນທີ່ເກັບກຳ ໃນຊ່ວງໄລຍະການຄົ້ນ ຄວ້າທົດລອງ ລວມທັງຂໍ້ມູນທີ່ໄດ້ແຕ່ລະຄອບ ຄົວນັ້ນ ຈະປ້ອນຂໍ້ມູນທີ່ໄດ້ ເຂົ້າໃນຄອມພິວເຕີ ແລ້ວທຳການຄິດໄລ່ ໂດຍນຳໃຊ້ການວິເຄາະຂໍ້ ມູນ ດ້ວຍລະບົບ ANOVA, ນຳໃຊ້ General Linear Model (Minitab, 2000). ເພື່ອຫາຕົວ ເລກ ຄວາມແຕກຕ່າງກັນ ທາງດ້ານສະຖິຕິ ກໍ່ຄື ລະດັບຄວາມເປັນໄປໄດ້ (Probability) $P<0.05$.

VIII. ຜົນໄດ້ຮັບ

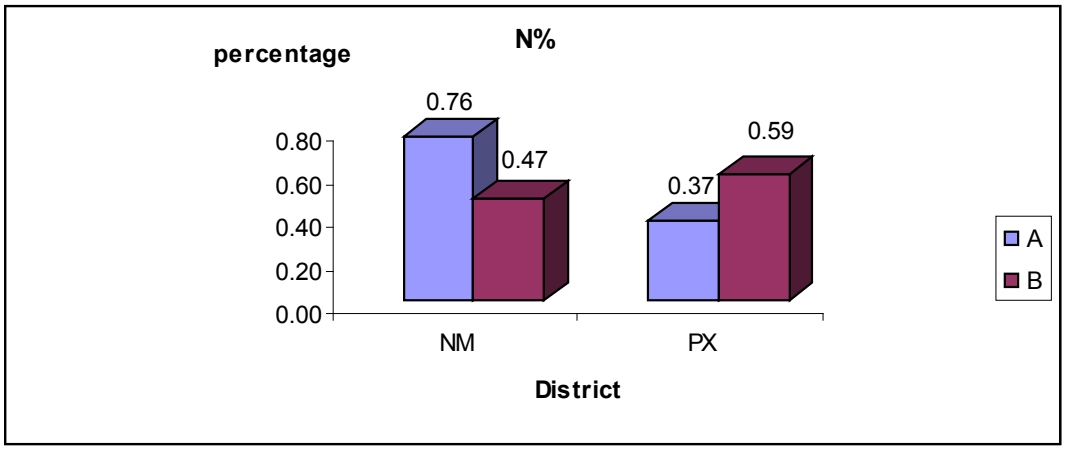
1. ຜົນການວິໃຈຝຸ່ນຄອກໄດ້ຈາກການລ້ຽງໝູ

ຕາຕະລາງ 3: ອົງປະກອບທາງເຄມີ NPK ຂອງຝຸ່ນຄອກ (%)

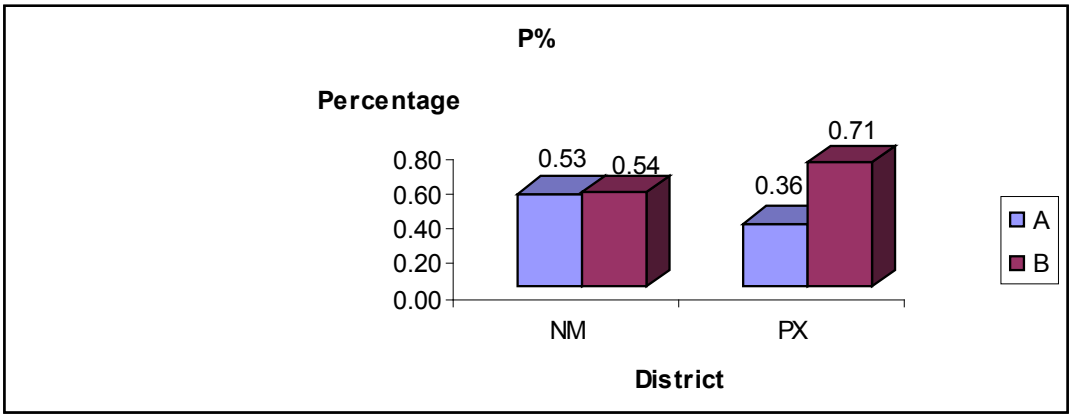
ທາດເຄມີ	ຈຸທົດລອງ ທີ 1		ຈຸທົດລອງ ທີ 2	
	ນາໝໍ້	ໂພນໄຊ	ນາໝໍ້	ໂພນໄຊ
N%	0.76	0.37	0.47	0.59
P%	0.53	0.36	0.54	0.71
K%	0.75	0.96	0.68	0.81

ຜ່ານການວິໃຈຫາອົງປະກອບທາງເຄມີ NPK ຂອງ ຝຸ່ນຂີ້ໝູ ຢູ່ສອງເມືອງ ລະຫວ່າງສອງຈຸ ທົດລອງ ແມ່ນບໍ່ມີຄວາມແຕກຕ່າງກັນ ທາງດ້ານສະຖິຕິ, ແຕ່ເຫັນວ່າ ຢູ່ເມືອງນາໝໍ້ ໃນຈຸທີ 1 ທາດ N% ແລະ P% ມີສູງກວ່າ ເມືອງໂພນໄຊ; ສ່ວນເມືອງໂພນໄຊ ຢູ່ໃນຈຸທີ ສອງ ທາດ N%, P% ແລະ K% ມີສູງກວ່າ ເມືອງນາໝໍ້.

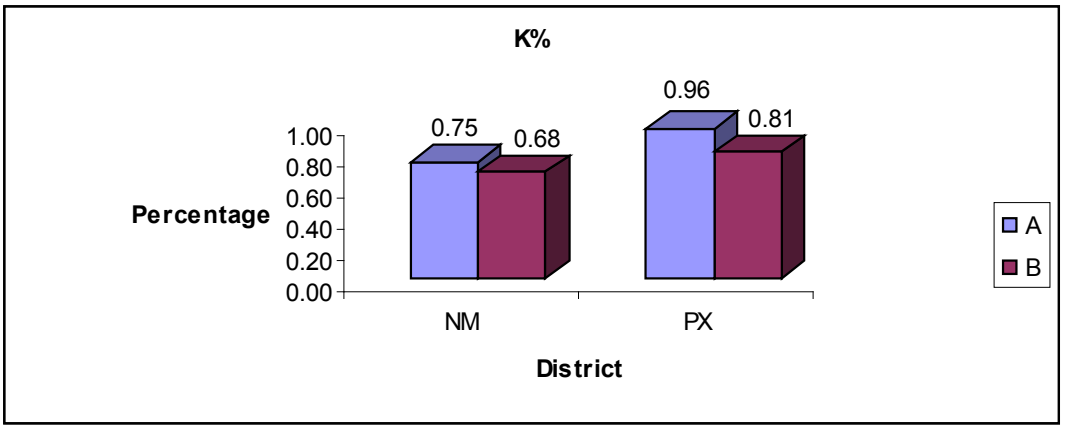
ຮູບສະແດງ 1: ສົມທຽບການບັນຈຸທາດ N (%)



ຮູບສະແດງ 2: ສົມທຽບການບັນຈຸທາດ P (%)



ຮູບສະແດງ 3: ສົມທຽບການບັນຈຸທາດ K (%)



1. ດ້ານອາຫານສັດ

ອາຫານຂອງໝູທົດລອງ ແມ່ນໄດ້ນຳໃຊ້ອາຫານທີ່ມີໃນທ້ອງຖິ່ນ ຊຶ່ງເໝາະກັບແນວພັນໝູລາດເຂດພູດອຍ ເຊັ່ນ: ປະເພດຮຳ, ສາລີ, ຕົ້ນບອນ. ອາຫານປະເພດນີ້ ເຂົາເຈົ້າຫາໄດ້ງ່າຍ ມີລາຄາຖືກ, ສ່ວນໃບບອນ ແມ່ນມີທົ່ວໄປຕາມປ່າທຳມະຊາດ.

ຕາຕະລາງ 4: ອົງປະກອບທາງເຄມີຂອງອາຫານ

ຊະນິດອາຫານ	ໂພນໄຊ		ນາໝໍ້	
	DM %	CP%	DM%	CP%
ຮຳອ່ອນ	90	10	87	09
ສະໄຕໂລ	20	19	20	18
ບອນ (ຕົ້ມ)	-	-	-	-

ແຫຼ່ງຂໍ້ມູນ ຈາກ: ສູນຄົ້ນຄວ້າການລ້ຽງສັດ 2007

ອີງຕາມຜົນຂອງການວິໃຈອາຫານສັດທີ່ເຂົາເຈົ້ານຳໃຊ້ ເຫັນວ່າ ຄຸນຄ່າອາຫານສັດ ໂດຍສະເພາະ ແມ່ນ DM, CP ຂອງອາຫານປະເພດ ຮຳ ຂອງ ເມືອງໂພນໄຊ ຈະສູງກວ່າ ຂອງເມືອງນາໝໍ້ ພຽງເລັກນ້ອຍ.

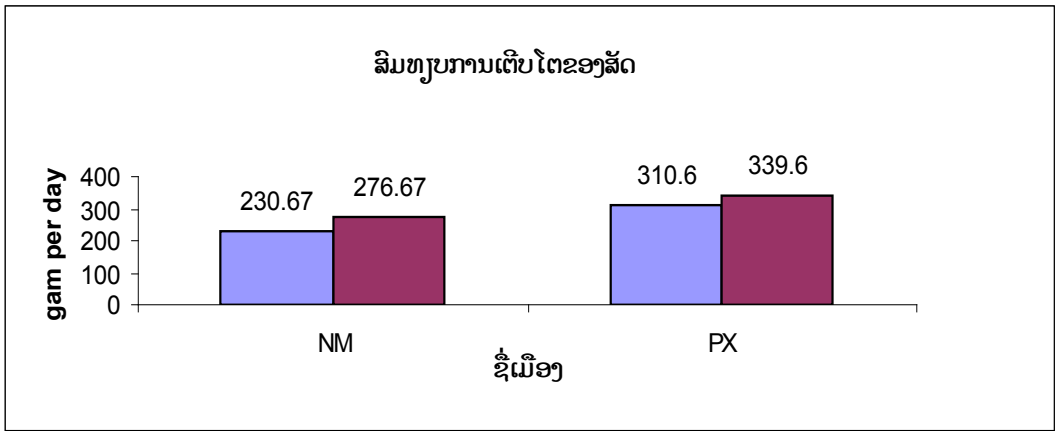
2. ການເພີ້ມນ້ຳໜັກ ຂອງ ສັດ ຕໍ່ມື້ ໂດຍສະເລ່ຍ

ສົມທຽບການໃຫ້ນ້ຳໜັກ ຂອງ ສັດ ໃນສອງຈຸທົດລອງ ໃນແຕ່ລະເມືອງ ເຫັນວ່າ: ການເພີ້ມນ້ຳໜັກສັດ ໃນຈຸທີສອງ ແມ່ນດີກວ່າຈຸທີນຶ່ງ ແຕ່ວ່າ ບໍ່ມີຄວາມແຕກຕ່າງກັນ ທາງດ້ານສະຖິຕິ (P>0.05). ໃນນີ້ ນ້ຳໜັກສັດ ຂອງ ເມືອງໂພນໄຊ ແມ່ນດີກວ່າ ຂອງ ເມືອງນາໝໍ້.

ຕາຕະລາງ 5: ການຈະເລີນເຕີບໂຕຂອງສັດ (ກຼາມ/ໂຕ/ວັນ)

ຈຸທົດລອງ	ໂພນໄຊ	ນາໝໍ້
1	310.6	230.6
2	339.6	276.6

ຮູບສະແດງ 4: ການຈະເລີນເຕີບໂຕຂອງສັດ (ກຼາມ/ໂຕ/ວັນ)



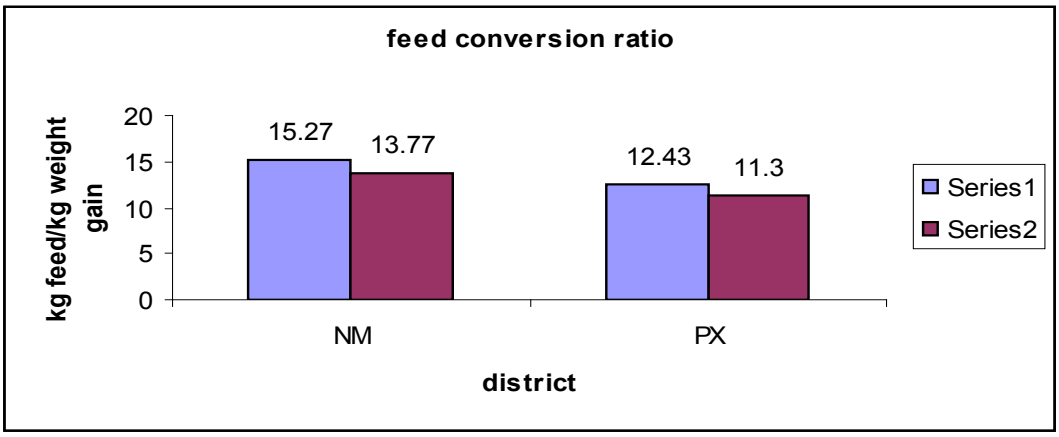
3. ອັດຕາການແລກປ່ຽນອາຫານເປັນຊີ້ນ (FCR)

ອັດຕາການແລກປ່ຽນອາຫານເປັນຊີ້ນ (FCR) ລະຫວ່າງ ສອງຈຸທົດລອງ ຂອງ ສອງເມືອງ ແມ່ນບໍ່ມີການແຕກຕ່າງ ທາງດ້ານສະຖິຕິ, ແຕ່ວ່າ FCR ຂອງ ເມືອງໂພນໄຊ ດີກວ່າ ເມືອງນາໝໍ້ ຄື: ຈຸທີ 2 ເມືອງໂພນໄຊ ແມ່ນ 11.3 ແລະ ເມືອງນາໝໍ້ ແມ່ນ 13.7 ຕາມລຳດັບ.

ຕາຕະລາງ 6: ການແລກປ່ຽນອາຫານ (ກິໂລອາຫານສົດ/ກິໂລຊີ້ນ)

ຈຸທົດລອງ	ໂພນໄຊ	ນາໝໍ້
1	12.4	15.2
2	11.3	13.7

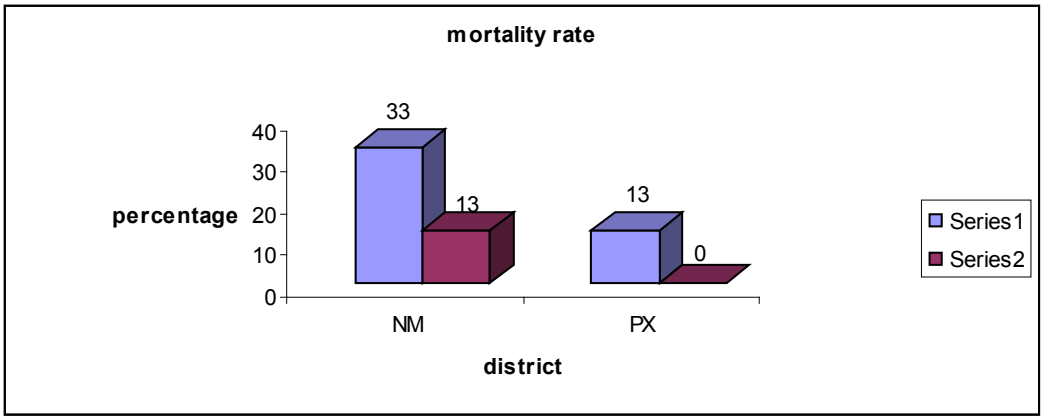
ຮູບສະແດງ 5: ການແລກປ່ຽນອາຫານເປັນຊີ້ນ (FCR)



4. ອັດຕາການຕາຍຂອງສັດ (%)

ອັດຕາການຕາຍຂອງສັດ ໃນຈຸທີ 1 ແມ່ນສູງເຖິງ 33% ຂອງ ເມືອງນາໝໍ້ 13% ຂອງ ເມືອງ ໂພນໄຊ. ອັດຕາການຕາຍຕ່ຳສຸດ ແມ່ນຢູ່ຈຸທີ 2 ຄື: 13% ຂອງ ເມືອງນາໝໍ້ ແລະ 0% ຂອງ ເມືອງ ໂພນໄຊ.

ຮູບສະແດງ 6: ອັດຕາການຕາຍ ຂອງສັດ (%)



IX. ການຕີລາຄາ ແລະ ປະເມີນຜົນ ແບບມີສ່ວນຮ່ວມ ຂອງ ຊາວກະສິກອນ ທັງສອງເມືອງ

ຈຸດດີ	- ໄດ້ຝຸ່ນຄອກ ທີ່ມີຄຸນນະພາບ 5-6 ໂຕນ/ຊຸມ (ສາມາດໃສ່ຕົ້ນໄມ້ໃຫ້ໝາກ ໄດ້ 800 - 1,000 ຕົ້ນ) - ມີກຳໄລຈາກການລ້ຽງໝູ ສະເລ່ຍ ຄອບຄົວ ລະ 400,000 ຫາ 600,000 ກີບ - ຮັກສາສິ່ງແວດລ້ອມໄດ້ດີ ຄອກໝູ ບໍ່ມີກິ່ນເໝັນ - ຮູ້ວິທີການຜະລິດນ້ຳຫົວເຊື້ອ ຊີວະພາບ (EM) ດ້ວຍຕົນເອງ
ຈຸດອ່ອນ	- ວັດສະດຸຮອງພື້ນຄອກ ບໍ່ພຽງພໍ ເຊັ່ນ: ແກບ - ປູກຫຍ້າສະໄຕໂລ ຊັກຊ້າ ບໍ່ທັນລະດູການ - ຂະໜາດ ຂອງ ແນວພັນສັດ ບໍ່ສະໝ່ຳສະເໝີກັນ - ຂາດຮຳເກືອໝູ ໃນລະດູການຜະລິດ
ໂອກາດ	- ການຕະຫຼາດດີ ລາຄາຂາຍໝູດີ - ສາມາດນຳໃຊ້ອາຫານໃນທ້ອງຖິ່ນ ລາຄາຖືກ ປະຢັດຕົ້ນທຶນໄດ້ດີ - ມີທຶນຮອນ ແລະ ພະນັກງານ ວິຊາການ ຂອງ ໂຄງການ ລົງສົ່ງເສີມການລ້ຽງສັດ
ແນວໂນ້ມ	- ມີຊາວກະສິກອນ 20 ຄອບຄົວ ຕ້ອງການຢາກລ້ຽງໝູ ຂອງ ໂຄງການຕໍ່ໄປອີກ

X. ไล่ลุ่งเสดถะกิด

ตาตะลาง 7: ลายรับ ແລະ ลายจ่าย ในกานลุ้งพู ซะลิดฝุ่นถอก ในสองรูบแบบ ของสองเมือง (ถิดไล่สะเล่ย ต่ำนึ่งถอบถิ่ว)

ลายกาน	แรงกาน	หัวหน่วย กิบ/โต	ลวม มูนค่ากิบ	พายเหด
ติ้นทืน ของ กานทิดลอง จุที 1				
ค่าแรงงานทั่งพิด			740,000	
อุปะกอนรับใช้			100,000	
แมวพันสัด			900,000	
อาหานสัด			100,000	ธำ, บอม
ลวมติ้นทืน (ลายจ่าย)			1,840,000	
ลวมลายรับ		*450,000 x 5*	2,250,000	
ดุ่นด่วง (ลายรับ-ลายจ่าย)			+410,000	
ติ้นทืน ของ กานทิดลอง จุที 2				
ค่าแรงงานทั่งพิด			740,000	
อุปะกอนรับใช้			100,000	
แมวพันสัด			900,000	
อาหานสัด			150,000	ธำ,บอม,สะไตโล
ลวมติ้นทืน (ลายจ่าย)			1,890,000	
ลวมลายรับ		*500,000 x 5*	2,500,000	
ดุ่นด่วง (ลายรับ-ลายจ่าย)			+610,000	

XI. ສະຫຼຸບ

ການລ້ຽງໝູ ຜະລິດຝຸ່ນຄອກ ຮ່ວມກັບ ຊາວກະສິກອນ ເຂດພູດອຍ ທັ້ງສອງຈຸທົດລອງ ສາມາດຊ່ວຍໃຫ້ເຂົາເຈົ້າໄດ້ຝຸ່ນຄອກຄຸນນະພາບ 5-6 ໂຕນ ຕໍ່ນຶ່ງຄອບຄົວ ສາມາດນຳໄປໃສ່ຕົ້ນ ໄມ້ໃຫ້ໝາກ ຫຼື ຢາງພາລາ ໄດ້ເຖິງ 1-2 ເຮັກຕາ.

ພາຍຫຼັງຈຳໜ່າຍໝູ ອອກສູ່ ຕະຫຼາດ ເຂົາເຈົ້າ ໄດ້ກຳໄລ 400,000 - 600,000 ກີບ ຕໍ່ນຶ່ງຄອບຄົວ ແລະ ໄດ້ຄວາມຮູ້ວິທີການຜະລິດ ນຳ້ສະກັດຊີວະພາບ ດ້ວຍຕົນເອງ; ບາງຄົນຍັງໄດ້ ສິດສອນເຕັກນິກໃໝ່ນີ້ ໃຫ້ແກ່ຜູ້ອື່ນ ທີ່ສົນໃຈນຳ ອີກ.

ຊາວບ້ານ ສາມາດນຳໃຊ້ກອງທຶນລ້ຽງໝູ ດັ່ງກ່າວ ເປັນອາຊີບຄົງທີ່, ຫຼຸດຜ່ອນການຖາງປ່າ ເຮັດໄຮ່ ແລະ ຊ່ວຍຫຼຸດຜ່ອນຄວາມຍາກຈົນ ໃຫ້ ແກ່ 12 ຄອບຄົວ ນຳອີກ.

ການລ້ຽງໝູ ຜະລິດຝຸ່ນຄອກ ຕາມເຕັກ ນິກໃໝ່ນີ້, ນອກຈາກ ບໍ່ເປັນອັນຕະລາຍຕໍ່ສຸຂະ ພາບຂອງຄົນເຮົາແລ້ວ ຍັງສ້າງລາຍໄດ້ດີ ແລ້ວ ມັນຍັງຊ່ວຍຮັກສາສະພາບແວດລ້ອມ ອ້ອມຂ້າງ ໄດ້ດີອີກ, ນີ້ແມ່ນສາເຫດນຶ່ງ ທີ່ໄດ້ມີຊາວກະສິ ກອນ ຈຳນວນ 20 ຄອບຄົວ ມີຄວາມຕ້ອງການໃຫ້ ໂຄງການສືບຕໍ່ໄປອີກ.

XII. ຂໍ້ແນະນຳ

ຄວນຂະຫຍາຍ ແລະ ສົ່ງເສີມຜົນໄດ້ຮັບ ຈາກການຄົ້ນຄວ້າທົດລອງຄັ້ງນີ້ ໃຫ້ແກ່ຊາວກະສິ ກອນຢ່າງກວ້າງຂວາງ.

ກິດຈະກຳ ຄວນເລີ້ມຕົ້ນຈັດຕັ້ງປະຕິບັດ ພາຍຫຼັງ ການເກັບກູ້ຜົນຜະລິດ ຂອງ ຊາວກະສິ ກອນ.

ຄວນຄັດເລືອກແນວພັນສັດ ທີ່ຈະເຮັດ ການທົດລອງໃຫ້ເໝາະສົມ ແລະ ສະໝ່ຳສະເໝີ ກັນ ໂດຍມີນຳ້ໜັກ ແຕ່ 15 ຫາ 20 ກລ.

ຄວນເຮັດການທົດລອງນຳໃຊ້ແນວພັນ ໝູລູກຊອດ ຮ່ວມກັບຊາວກະສິກອນ.

ພະນັກງານ ວິຊາການ ພາກສະໜາມ ຄວນລົງຊຸກຍູ້ຕິດຕາມ ວຽກການຄົ້ນຄວ້າທົດລອງ ຮ່ວມກັບຊາວກະສິກອນ ໃຫ້ເປັນປົກກະຕິ.

ວິຊາການ ຄວນມີການຄົ້ນຄວ້າທົດລອງ ນຳໃຊ້ຝຸ່ນ ກັບພືດຕ່າງໆ ເພື່ອມີຂໍ້ມູນພື້ນຖານ.

XII. ເອກະສານອ້າງອີງ

ປຶ້ມຄູ່ມືນຳ້ສະກັດຊີວະພາບ ເພື່ອການ ປູກຝັງ ລ້ຽງສັດ ແລະ ສິ່ງແວດລ້ອມ, ພະແນກກະ ສິກຳ ແລະ ປ່າໄມ້ ກຳແພງນະຄອນວຽງຈັນ 2004.

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ຄູ່ມືການລ້ຽງໝູແບບທຳມະຊາດຂອງ ເກົາຫຼີ, Northern Sustainable Development Leaning Center (Thailand) Email adress: chokchai26@hotmail.com

ຮູບສະແດງ 7: ໝູພັນພື້ນເມືອງລາວ ທີ່ລ້ຽງໃນຂຸມ

ສຶກສາ ການຄຳນວນ Phosphorus Buffer Coefficients ຂອງ ຊຸດດິນ ທີ່ເປັນຕົວແທນໃນການຜະລິດສາລີ ຢູ່ ສປປ ລາວ

ຄອນປານີ ດຸ່ນຜາດີ[1], Tasnee Attanandana[2] ແລະ Russell Yost[3]

ບົດຄັດຫຍໍ້

Phosphorus Buffer Coefficient (PBC) ເປັນປັດໄຈນຶ່ງທີ່ສຳຄັນໃນໂປຣແກມ Phosphorus Decision Support System (PDSS). ທີ່ໃຊ້ໃນການຄິດໄລ່ ອັດຕາຝຸ່ນຟົສຟໍຣັດເພື່ອແນະນຳຕໍ່ການຜະລິດສາລີ. ຊຸດດິນ 7 ຊຸດ ທີ່ເປັນຕົວແທນສຳຄັນ ໃນການຜະລິດສາລີ ຢູ່ ສປປ ລາວ ແລະ 1 ຊຸດ ຢູ່ ປະເທດໄທ ໄດ້ນຳມາສຶກສາຫາຄ່າ PBC. ຄ່າ PBC ຫາໄດ້ໂດຍການປະສົມດິນຕົວຢ່າງກັບ potassium dihydrogen phosphate (KH_2PO_4) ໃນອັດຕາ 0, 25, 50, 100 ແລະ 200 mg P kg^{-1} ດິນ ແລ້ວ ບົ່ມ ໃນອຸນຫະພູມ 30 ອົງສາເຊ ເປັນເວລາ 2 ອາທິດ, ຈາກນັ້ນ ນຳດິນມາວິເຄາະຫາຫາດ ຟົສຟໍຣັດ ດ້ວຍວິທີ ຂອງ Mehlich 1($PBC_{Mehlich\ 1}$), Bray 2 ($PBC_{Bray\ 2}$) ແລະ Pi-test ($PBC_{Pi\text{-}test}$) ຜົນການວິໄຈ ສະແດງໃຫ້ເຫັນວ່າ: ຄ່າຂອງ PBC ມີຄວາມແຕກຕ່າງກັນ ຕາມວິທີການວິເຄາະ ຟົສຟໍຣັດ ແລະ ການສຶກສາຄວາມສຳພັນ ລະຫວ່າງ ຄ່າ PBC ກັບຄຸນສົມບັດຕ່າງໆຂອງດິນ ໂດຍການໃຊ້ Muliple recgeasesion analysis ພົບວ່າ ຄ່າ $PBC_{Bray\ -2}$ ແລະ $PBC_{Mehlich-1}$ ມີຄວາມສຳພັນກັບເປີເຊັນດິນໜຽວ (Clay) ໂດຍມີຄ່າ $adjR^2$= 0.64, 0.43 ຕາມລຳດັບ. ເປີເຊັນດິນໜຽວ (Clay) ແລະ aluminum ທີ່ວິເຄາະດ້ວຍອາໂມນຽມອົກຊາເລດ (Al_o) ແມ່ນປັດໄຈສຳຄັນກະທົບຕໍ່ຄ່າ $PBC_{Pi\text{-}test}$ ໂດຍມີຄ່າ $adjR^2$= 0.89.

ຄຳສັບຫຼັກ: *phosphorus buffer coefficient, ດິນປູກສາລີ, ການດູດຊັບທາດຟົສຟໍຣັດ, ວິທີການໃຊ້ເຈ້ຍເຄືອບທາດເຫຼັກອົກຊາຍວິເຄາະທາດຟົສຟໍຣັດ.*

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Predicting Phosphorus Buffer Coefficients of Some Representative Soils for maize production in Lao PDR by three soil analysis methods

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Abstract

Phosphorus buffer coefficient (PBC) is one of the important factors in the phosphorus fertilizer recommendation prediction by PDSS program. The study on PBC of 7 representative maize soils from Laos and one Thai soil was conducted. The PBC determination was done by mixing the soils with potassium dihydrogen phosphate (KH_2PO_4) at the rates of 0, 25, 50, 100 and 200 mg P kg^{-1}. All soil samples were kept in the incubator at 30°C for two weeks. The extractable P was analyzed by three methods: Mehlich 1 ($PBC_{Mehlich\ 1}$), Bray 2 ($PBC_{Bray\ 2}$) and iron oxide-impregnated filter paper method or Pi-test ($PBC_{Pi\text{-}test}$). The results showed different PBC values of soils with different extractants. Multiple regression analysis was used to study the relationship between the PBC and soil properties. It revealed that $PBC_{Bray\text{-}2}$ and $PBC_{Mehlich\text{-}1}$ was correlated with percentage of clay content with adjR^2=0.64 and and 0.43, respectively. The percentage of clay and Al_o were the main factors affecting the $PBC_{Pi\text{-}test}$ with adjR^2 of 0.89.

Key words: *phosphorus buffer coefficient, maize soils, phosphorus sorption, iron oxide-impregnated filter paper method.*

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I. Introduction

The rates of recommended phosphorus fertilizer for maize production in the Lao PDR are not widely known. The major problems of maize production are the infertile soils with high soil acidity and low phosphorus content. Fertilizer application for maize production is very different in the production areas depending on the economy of the farmers rather than on the nutrient needs of the plants (Lathvilayvong, 2000).

The soils are poor in N, P and K. Soils with content of extractable P of less than 10 mg kg^{-1} cover about 97% of the total cultivated area of the country, soils with extractable K of less than 40 mg kg^{-1} cover about 71%, soils with pH ranging from 4.1 to 5 cover 78%, and soils with the percentage of organic matter of less than 2 g kg^{-1} cover 87% (Vonghachack, 2000).

In Thailand, the new technology for phosphorus and potassium fertilizer requirement prediction using Phosphorus Decision Support System (PDSS) program has been successfully used for maize production. The use of the decision-aids has resulted in reduced fertilizer P applications, and the farmers accepted the recommendations (Attanandana *et al.*, 2000). Phosphorus buffer coefficient (PBC) is an important variable in the PDSS program (Chen *et al*., 1997).

In Thailand, Bray-2 extraction is widely used to estimate soil available P. The second most popular extractant used by Kasetsart University is Mehlich-1 method, a dilute double acid extractant. Both of these methods have been found to correlate well with total P uptake of maize (Attanandana *et al*., 1999).

Yost *et al*. (1992) suggested that characterization of the buffer coefficient should be possible by quantifying soil properties that determine P sorption. Wright *et al*. (1992) estimated P buffering coefficient by relating the P buffering coefficient to soil pH and P retention as estimated by Saunder (1965)'s method. Hughes and Gilkes (1994) and Cox (1994) predicted P buffering coefficient by clay content in the soil. Smyth and Sanchez (1982) proposed that the soils having the highest clay and free Fe_2O_3 contents had the highest P sorption capacity. Soil pH significantly influences other soil chemical properties.

Brady (1990) suggested that, when the pH falls below 6.0, the availability of nutrients such as phosphorus, potassium, calcium, and magnesium decreases. Phosphate availability also tends to decrease at high soil pH, because of precipitation as insoluble

calcium phosphate compounds. The pH range of greatest phosphate availability is about 6 to 7 for most agricultural soils (Bohn *et al.*, 1985). Also Shahandeh *et al*. (1994) observed that soil with high levels of oxalate extractable Fe sorbed more P under reduced conditions.

The objective of this study is, therefore, to study the PBC of eight representative soils for maize production in Laos and Thailand by Mehlich-1, Bray 2 and Pi-test methods. Moreover, the study on relationship of PBC with soil properties using stepwise multiple regression analysis was also included.

II. Materials and Methods

Soil

Seven soils representing the important soils for maize production in the Lao PDR were selected for the experiment. These included the Hoysay soil (Hs), which was collected in Northern part of Laos in Hoysay district, Borkeo province. Three soil samples were selected from Central Laos, namely: Pek soil (Pe), and Phasay soil (Ps), which were collected in Pek and Phasay districts, Xiengkhouang province, and the Saythong soil (St) was collected in Nasaythong district, Vientiane capital, Laos, respectively. Two soil samples; Bachieng soil (Bc) and Hoythakoune soil (Hk) were selected in Southern part in Bachieng and Pathomphone districts, Champasak province, and Vapi soil (Vp) was selected from Vapi district, Saravanh province, Laos, respectively. In addition the Khon Kaen soil (Kk) from Thailand was included. Most soils from Laos and that from Thailand were Ultisols except for the Bc soil which is an Oxisol. All soil samples were collected from the surface horizon 0-20 cm depth. Air-dried soil samples were ground and passed through a 2-mm sieve and thoroughly mixed.

Soil analysis

Soil chemical and physical properties were determined as follows: Soil texture was determined by the pipette method (Day, 1965), soil pH by glass electrode (soil water ratio of 1:1), organic matter by Walkley Black titration (Walkley and Black, 1934) and cation exchange capacity (CEC) by ammonium acetate pH 7 method (Rhoades, 1982). Extractable Al and Fe were measured by acid ammonium oxalate, citrate-bicarbonate-dithionite methods (Loeppert and Inskeep, 1996) and by 1*M* KCl. Extractable Fe, Cu, Mn, and Zn were determined by diethylenetriaminepentaacertic acid, (DTPA) pH 7.3 (Tan, 2005). Exchangeable K, Ca, Mg and Na by NH_4OAc pH 7 (Jones, 2001). Available P was extracted by Bray 2 (Bray and Kurtz, 1945), Mehlich-1 (Mehlich,

1953), and Pi-test methods (Myers *et al*., 1995; Chardon, 1996; Chardon *et al*., 2000). Total P was analyzed by Conc. HNO_3-H_2SO_4 -$HClO_4$, with the ratio of 5:1:2 (Yoshida *et al*., 1972). Total N was analyzed by the Kjeldhal method (Bremner, 1996).

Phosphorus buffer coefficient (BPC) of soils

Soil incubation

Five grams of each soil sample was mixed with potassium dihydrogen phosphate (KH_2PO_4) at the rates of 0, 25, 50, 100 and 200 mg P kg^{-1}. The soil mixtures were then added with distilled water to reach field capacity moisture level. All soil samples were kept in the incubator at 30°C for two weeks. The extractable P was analyzed by three methods: Bray 2, Mehlch-1 and Pi-test.

PBC calculation and correlation with soil propertiesSeven

Phosphorus buffer coefficients (PBC) were estimated from the slope of linear regression of extractable phosphorus versus phosphorus fertilizer added after 2 weeks of incubation. The PBC values of each soil from the three methods were correlated with some soil properties using stepwise multiple regression analysis.

Iron oxide-impregnated filter paper method (P-test)

FeO paper preparation: A 5.5 cm disc of ash free, hard filter paper Whatman no 50 (2.7 µm pore openings) was immersed in acidified $FeCl_3$ for 5 minutes. The paper was drip dried at room temperate for 1 hour. The paper was then treated with NH_3 vapor through a bath containing 5% of NH_4OH until the paper color changed from yellow to brown. Since NH_4Cl can lower pH level, causing the increase of P concentration in soil solution, the FeO paper was washed with distilled water several times to get rid of NH_4Cl. After air-dried, the paper was kept in the closed pack.

Shaking soil suspension with FeO paper: one gram of soil was shaken with 40 ml of 0.01 *M* of $CaCl_2$ solution. One FeO paper protected by polyethylene screen with 0.1 mm opening in a fix position was shaken with soil suspension on a reciprocating shaker at a speed of 30 excursions min^{-1} for 16 hours. The paper was taken out and thoroughly rinsed with distilled water to remove adhering soil particles.

Determination of P extracted by FeO paper: The FeO with adsorbed P was dissolved by shaking in 40 ml of 0.1 *M* H_2SO_4 for 1 hour, then filtered and the filtrate was saved for P measurement.

III. Results and Discussion

Soil properties studied

Soil chemical and physical analyses are shown in Table 1. All soils were acidic with pH ranging from 4.3 to 5.5. The clay content of these soils was higher than 200 g kg^{-1}, except Kk soil which was very low in clay with 63 g kg^{-1} while the highest was the Vp soil with 574 g kg^{-1}. The amounts of Fe extracted by citrate-dithionite (Fe_d) ranged from 1.19 to 55.2 g kg^{-1} and Al_d ranged from 23.3 to 31.5 g kg^{-1}. The amounts of Fe_d and Al_d in the Bc soil was the highest among the selected soils studied. Extractable P of the Hs soil by Bray 2, Mehlich-1 and Pi-test was higher than those of the other soils of 41.2, 15.6 and 18.0 mg kg^{-1}, respectively.

Phosphorus buffer coefficient (PBC)

A phosphorus buffer coefficient is an indicator of the change in extractable P per unit change of P added. High values indicate less reaction of the soils with the added P and low values indicate a higher degree of reaction of the soils with the added P.

In this study, the PBC values of each soil from the three methods were different. The PBC values of Kk soil from the three methods were higher than those of the other soils (Table 2). This high PBC value indicated low P sorption. The Kk soil amounts of clay content, Fe_o, Fe_d and Al_o were lower than the other soils. In contrast the PBC of Bc, and Vp soils by three extractants were lower than the other soils.

It was noted that the clay content, amount of Fed in Bc soil, Ald in Vp soils were higher compared to the other soils (Table 1). Clay mineral and extractable Al, Fe all play an important role in P sorption (Agbenin, 2003). In the same way Wiriyakitnateekul *et al*. (2005) reported that in Thai soils, 81% of variability in P sorption was related to Fe and Al dithionite and oxalate extraction. Normally PBC values estimated by Bray 2 are higher than PBC estimated by Mehlich-1 and Pi-test, respectively (Yampracha, 2006). In contrast, in this experiment the PBC values of some soils which were estimated by Pi-test method were higher than PBC value estimated by Mehlich-1 except for the Kk soil.

Predicting PBC using soil properties

The relationship between soil properties and PBC values was determined by stepwise multiple regression analysis. The soil properties affecting the PBC calculation for each method were different with different methods. In model (1) and model (2)

$PBC_{Bray\ 2}$ and $PBC_{Mehlich\text{-}1}$ was correlated with % clay content alone with adjR^2 of 0.64 and 0.43, respectively. The percentage of clay and Al_o were the main factors affecting the $PBC_{Pi\text{-}test}$ with adjR^2 of 0.89 (Table 3).

To describe the relationships between the soil properties and PBC values, the clay and Alo were important soil properties. The $PBC_{Bray\text{-}2}$ and $PBC_{Mehlich\text{-}1}$ decreased with increasing % clay content (Table3). Wang *et al*. (2000) observed that clay content had little correlation with PBC but high correlation of P sorption capacity was observed with the amorphous materials, mainly Al and Fe oxides. Poudel and West (1999) reported that the maximum phosphate sorption of Oxisols, Ultisols and Inceptisols in Philippines ranged from 6,944 to 14,208 µg P g^{-1}, and it was closely related with Alo and clay content. $PBC_{Pi\text{-}test}$ was correlated with % clay content and Al_o with adjR^2 of 0.89. Bruland and Richardson (2004) found that Al_o had the highest correlation with phosphorus sorption index. Also Maguire *et al*. (2001) reported that sorption of P was strongly correlated with the amounts of Al_o and Fe_o. In addition, Wang et al. (2001) mentioned that many soils with high P retention contained high levels of Fe and Al extractable-oxalate. The effect of Al_o on PBC occurring in the third model was not uncommon because the ammonium oxalate extraction is selective for amorphous Fe and Al compounds that contain large amounts of surface area reactive with P.

Soil properties were substituted into models (1), (2) and (3) to predict the $PBC_{Bray\ 2}$, $PBC_{Mehlich\text{-}1}$ and $PBC_{Pi\text{-}test}$. The predicted PBC was plotted against the observed PBC to compare the predictability of the models (Figure 1).

The relationships in (Figure 1A and 1B) showed that the predicted $PBC_{Bray\ 2}$ and predicted $PBC_{Mehlich\text{-}1}$ were higher than the observed PBC for several soils. The predicted PBC in model (3) was very close to the observed PBC, the points being distributed along with the 1:1 line (Figure 1C), these illustrates that the PBC of the Pi-test could be better predicted that of other extractants.

IV. Conclusions

The major problems of maize production in Laos are acidic soil and low P content. Seven sites representative of maize production areas in Laos and in addition the Khon Kaen soil from Thailand were selected to predict P requirements by Phosphorus Decision Support System (PDSS) program.

Phosphorus buffer coefficients (PBC) were determined using three soil extraction methods namely: Bray 2, Mehlich-1 and

Pi-test. The PBC values of eight selected soils differed with different methods of P extraction. As expected from strong extractants the $PBC_{Bray\ 2}$ was higher than $PBC_{Mehlicl-1}$ and $PBC_{Pi-test}$. The PBC values were correlated with some selected soil properties, the $PBC_{Bray\ 2}$ and $PBC_{Mehlich\ 1}$ decreased with the increasing of percentage of clay content. Percentage of clay content and acid ammonium oxalate extractable aluminum were the main factors affecting the $PBC_{Pi-test}$.

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VII. Annexes

Table 1: Characteristics of the eight soil samples before conducting experiments

Soil properties	Contents							
	Hs	Bc	Pe	Ps	Vp	Hk	St	Kk
Texture	Silt loam	Clay	Silty clay loam	Silt loam	Clay	Silty clay loam	Clay	Sand
Clay (g kg^{-1})[1]	245	407	270	215	574	203	289	63.0
Soil pH[2]	5.5	4.3	4.6	4.8	5.5	4.7	5.3	4.4
OM (g kg^{-1}) [3]	21.1	49.6	55.2	54.1	16.6	12.7	30.0	8.6
CEC ($cmol_c kg^{-1}$)[4]	14.6	24.7	17.8	22.4	20.6	8.6	17.8	3.00
Total N(g kg^{-1})[5]	0.60	0.80	1.00	1.80	0.50	0.40	0.80	0.20
Total P (g kg^{-1}) [6]	4.50	1.90	2.40	4.00	2.60	3.00	3.90	0.00
P (mg kg^{-1})[7]	41.2	1.56	1.80	6.26	0.26	0.42	14.7	6.29
P (mg kg^{-1})[8]	15.6	0.12	0.16	0.67	0.10	0.16	4.09	3.40
P (mg kg^{-1})[9]	18.0	4.17	3.33	3.56	0.82	2.01	4.86	3.04
K ($cmol_c kg^{-1}$)[10]	0.24	0.11	0.12	0.10	0.08	0.27	0.23	0.09
Ca ($cmol_c kg^{-1}$)[10]	1.18	0.21	0.56	0.09	0.72	0.32	0.78	0.30
Mg ($cmol_c kg^{-1}$)[10]	0.68	0.18	0.09	0.05	1.02	0.30	0.68	0.13
Na ($cmol_c kg^{-1}$)[10]	0.34	0.31	0.33	0.49	0.46	0.31	0.35	0.53
Fe_o (g kg^{-1})[11]	3.15	2.93	1.62	0.94	2.56	1.53	2.19	0.58
Fe_d (g kg^{-1})[12]	11.9	55.2	16.5	2.56	13.1	9.03	9.58	1.19
Al_o (g kg^{-1})[13]	0.80	3.60	1.55	5.57	1.64	1.16	2.68	0.43
Al_d (g kg^{-1})[14]	23.3	31.5	28.2	27.8	28.0	25.2	27.4	27.5

[1] Pipette method (Day, 1965); [2] Glass electrode, 1:1 soil: water ratio; [3] Walkley Black titration (Walkley and Black, 1934); [4] NH_4OAc, pH7 replacement method (Rhoades, 1982); [5] Macro Kjeldhal methods (Bremner, 1996); [6] Conc. HNO_3-H_2SO_4- HC_1O_4, ratio 5:1:2 (Yoshida et al. 1972); [7] Bray 2 method (Bray and Kurtz, 1945); [8] Mehlich-1 method (Mehlich, 1953); [9] Pi-test (Myers *et al*., 1995, Chardon, 2000, Chardon *et al.*, 1996); [10] NH_4OAc pH 7 (Jones, 2001); [11, 13] Acid ammonium oxalate method (Loeppert and Inskeep, 1996); [12, 14] Citrate-bicarbonate-dithionite Method (Loeppert and Inskeep, 1996).

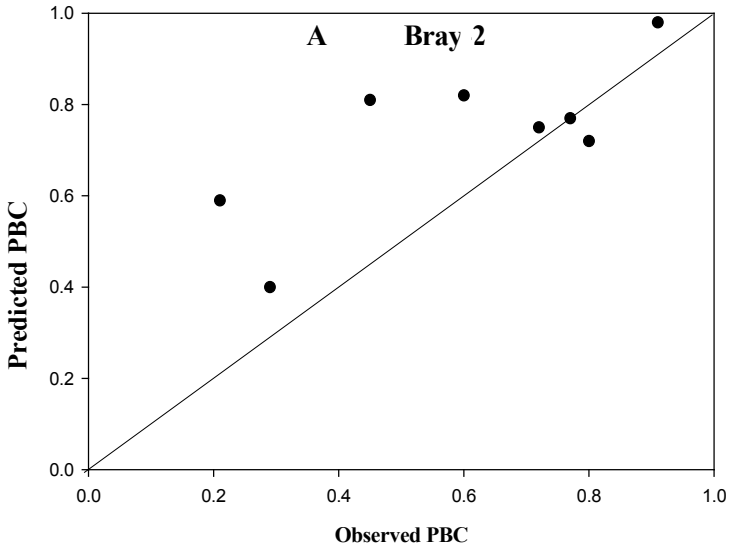
Table 2: Phosphorus buffer coefficient (PBC) values of 8 soil samples as determined by three extractant methods.

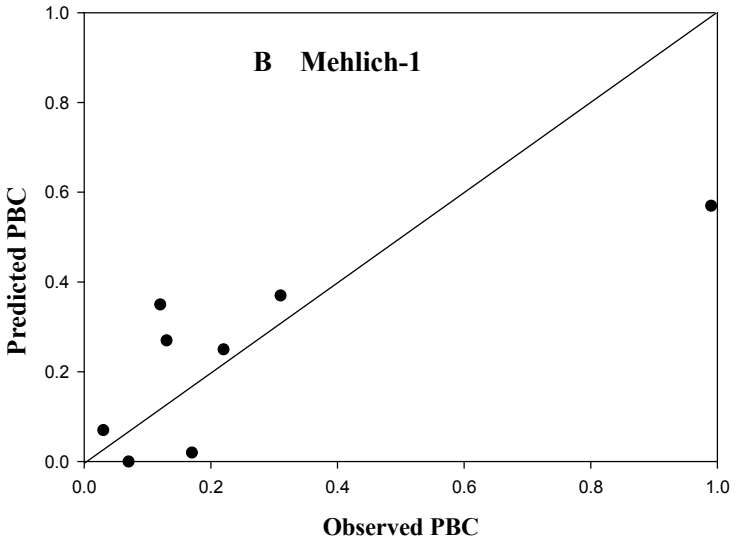
Soils	PBC values		
	Bray 2	Mehlich-1	Pi -test
Hs	0.77	0.17	0.65
Bc	0.21	0.03	0.12
Pe	0.72	0.13	0.65
Ps	0.45	0.12	0.19
Vp	0.29	0.07	0.21
Hk	0.60	0.31	0.51
St	0.80	0.22	0.40
Kk	0.91	0.99	0.85

Hs=Hoysay soil, Bc= Bachieng soil, Pe=Pek soil, Ps=Phasay soil, Vp=Vapi soil, Hk=Huoytakuoane soil, St=Saythong soil, Kk=Khon Kaen soil.

Table 3: Models and coefficients describing the PBC prediction of the soils studied.

Statistical model	adjR^2
(1) $PBC_{Bray\ 2}$ = 1.05-0.01% clay	0.64*
(2) $PBC_{Mehlich\text{-}1}$ = 0.67-0.01clay	0.43*
(3) $PBC_{Pi\text{-}test}$ = 0.96-0.01% clay -0.10 Al_o	0.89**


A Bray 2
Predicted PBC
Observed PBC
0.0
0.2
0.4
0.6
0.8
1.0


B Mehlich-1
Predicted PBC
Observed PBC
0.0
0.2
0.4
0.6
0.8
1.0

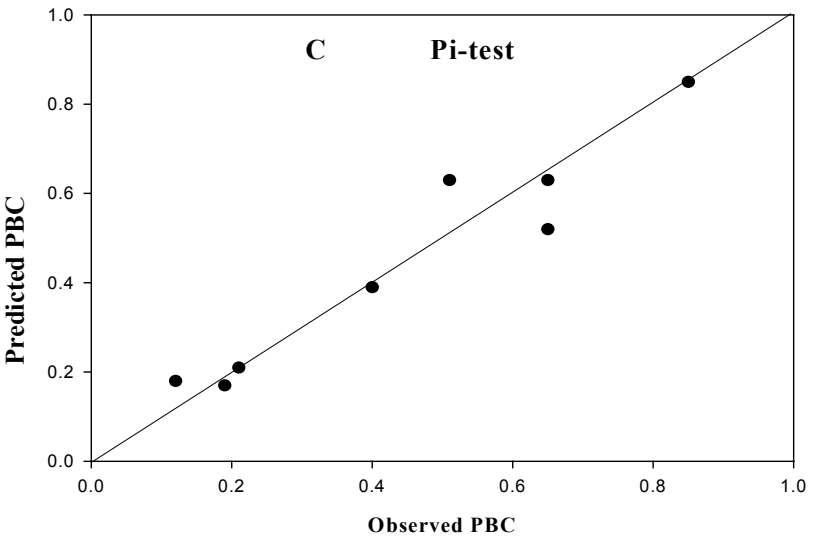


Figure A, B & C : Relationships between predicted and observed PBC by three different extractants

Figure 2: Maize experiment plot at Seandin, Naxaythong district, Vientiane Municipality.

ການທົດລອງແນວພັນ ແລະ ສາຍພັນສາລີລູກປະສົມ ຢູ່ ທົ່ງພຽງ ວຽງຈັນ ສປປ ລາວ

ຄຳຕອມ ອັນທານຸວົງ[1] ຫວຽນເທຮ໋ງ[2]

ບົດຄັດຫຍໍ້

ສາລີ (Zea mays L.) ແມ່ນພືດປູກປະເພດນຶ່ງ ທີ່ປະຊາຊົນລາວ ນິຍົມກັນປູກມາແຕ່ດົນນານ. ປະຈຸບັນ ຖືວ່າ ສາລີ ເປັນພືດເສດຖະກິດ ແລະ ເປັນສິນຄ້າສົ່ງອອກ ທີ່ສ້າງລາຍຮັບໃຫ້ແກ່ຊາວກະສິກອນ ເຮັດໃຫ້ຊີວິດການເປັນຢູ່ ຂອງເຂົາເຈົ້າ ນັບມື້ນັບດີຂຶ້ນເລື້ອຍໆ. ໃນໄລຍະ 7 ປີ ຜ່ານມາ, ເນື້ອທີ່ ຜະລິດສາລີ, ຜະລິດຕະພາບ ແລະ ຜົນຜະລິດ ໄດ້ເພີ້ມຂຶ້ນຢ່າງວ່ອງໄວ, ອີງຕາມຂໍ້ມູນສະຖິຕິ ຂອງ ກົມ ປູກຝັງ, ກະຊວງ ກະສິກຳ ແລະ ປ່າໄມ້ ປີ 2007, ລວມຍອດຜົນຜະລິດ ຂອງ ລາວ ໄດ້ເພີ້ມຂຶ້ນ ເປັນ 620,550 ໂຕນ. ຜະລິດຕະພາບ ສະເລ່ຍ 4.68 ໂຕນ/ເຮັກຕາ. ເພື່ອຕອບສະໜອງການຜະລິດ ໃນແຕ່ ລະປີ ໃຫ້ຫຼາຍຂຶ້ນ ຕ້ອງໄດ້ຄົ້ນຄວ້າທົດລອງ ແລະ ຄັດເລືອກແນວພັນສາລີ ຢ່າງເປັນປົກກະຕິ ເພື່ອໃຫ້ ໄດ້ແນວພັນທີ່ດີ ມີຄຸນນະພາບ ໃຫ້ຜົນຜະລິດສູງ ແລະ ແທດເໝາະກັບເງື່ອນໄຂສະພາບແວດລ້ອມ ຂອງ ທ້ອງຖິ່ນ.

ການທົດລອງ ໄດ້ປະຕິບັດ ໃນ 2 ລະດູ ຄື: ລະດູແລ້ງ ແລະ ລະດູຝົນ ປີ 2007.
- ລະດູຝົນ ລວມມີ 9 ແນວພັນ ແລະ 3 ສາຍພັນ
- ລະດູແລ້ງ ລວມມີ 8 ແນວພັນ ແລະ 7 ສາຍພັນ

ສາຍພັນດັ່ງກ່າວ ໄດ້ມາຈາກ ສາລີຄູ່ປະສົມ ຂອງ ບົດວິທະຍານິພົນ ການຄົ້ນຄວ້າສາລີ ສ່ວນ ແນວພັນ ແມ່ນສະຖາບັນຄົ້ນຄວ້າສາລີ ແລະ ໂຮງຮຽນກະສິກຳ ຮ່າໂນ້ຍ ສສ ວຽດນາມ ສະໜອງໃຫ້ ເພື່ອປູກທົດລອງ ແລະ ສົມທຽບກັບ ແນວພັນ LVN10 ແລະ CP888 ຊຶ່ງເປັນຕົວຢືນ.

ສະຖານທີ່ທົດລອງ: ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ, ວາງແປງທົດລອງແບບ RCB ມີ 3 ຊ້ຳ ແຕ່ລະຊ້ຳ ມີເນື້ອທີ່ທົດລອງ 14 ມ^2, ໄລຍະຫ່າງລະຫວ່າງແຖວ 70 ຊຕມ, ລະຫວ່າງຕົ້ນ 25 ຊຕມ. ສະເລ່ຍ 57,000 ຕົ້ນ/ຮຕ. ການໃສ່ຝຸ່ນສ່ວນຫຼາຍແມ່ນຝຸ່ນຄອກ ໂດຍໃສ່ປະສົມກັບ ຝຸ່ນວິທະຍາສາດ $150N + 60P_2O_5+60K_2O$.

[1]ກອງສົ່ງເສີມ ກະສິກຳ ແລະ ປ່າໄມ້ ແຫ່ງຊາດ, ກະຊວງ ກະສິກຳ ແລະ ປ່າໄມ້.
[2]ສະຖາບັນຄົ້ນຄວ້າສາລີ ແລະ ໂຮງຮຽນກະສິກຳ ຮ່າໂນ້ຍ, ສສ ວຽດນາມ

GRAIN YIELD TRIAL OF NEWLY HYBRID MAIZE VARIERIES AND COMBINATIONS IN THE VIENTIANE DELTA, LAO P.D.R.

Khamtom vanthanouvong[1] and Nguyen The Hung[2]

Abstract

Maize (Zea mays L.) is one of the most important cereal crops in Lao P.D.R. Maize production was also a substantial source of income for farmers and for export. During the last 7 years, the planted area, grain yield and total production of maize have been increasing rapidly in Laos. The total maize production in 2007 was 620,550 tons and the average yield was 4.68 tons per ha. In order to further increase maize yield in Laos, it is necessary to introduce and select suitable varieties for the agro-ecosystem conditions in each region. The objective of this work, therefore was to evaluate the adaptability and yield potential of newly maize hybrid varieties and combinations received from international institutions in the Vientiane Delta, Laos.

Nine newly hybrid maize varieties and three combinations was evaluated under the experimental field conditions in the summer cropping season at National Plant Breeding Research Center, Naphok, Laos. Another variety testing including eight hybrid varieties and seven combinations was also conducted in the winter cropping season. These hybrid varieties and combinations were received from National Maize Research Institute and Hanoi University of Agriculture, Vietnam. The check variety were LVN10 (Vietnamese variety) and CP888 (Thailand variety).

Experiments were laid out in the Randomized Complete Block Design (RCBD) with three replications. The plot area was 14 m^2. The spacing between rows was 70 cm and between hills was 25 cm. There was one plant per hill so that the plant population was 57,000 plants/ha. Fertilizer was applied basally at the rate of 10 tons manure + 150 kg N + 60 kg P_2O_5 + 60 kg K_2O ha.

[1]National Agriculture and Forestry Extention Service, Lao PDR.

[2]National Maize Research Institute and Hanoi University of Agriculture, Vietnam.

I. ບົດນຳ

ສາລີ (Zea mays L.) ແມ່ນພືດທັນຍາຫານ ປະເພດນຶ່ງ ທີ່ປະຊາຊົນລາວ ນິຍົມປູກມາແຕ່ດົນ ນານ. ປະຈຸບັນ ສາລີ ຖືວ່າ ເປັນພືດເສດຖະກິດທີ່ ສ້າງລາຍຮັບ ໃຫ້ແກ່ຊາວກະສິກອນ ແລະ ເຮັດ ໃຫ້ຊີວິດການເປັນຢູ່ ຂອງເຂົາເຈົ້າ ນັບມື້ນັບດີ ຂຶ້ນເລື້ອຍໆ ທັງເປັນສິນຄ້າສົ່ງອອກ ທີ່ສຳຄັນ. ໃນຊ່ວງ 7 ປີ ທີ່ຜ່ານມາ, ເນື້ອທີ່, ຜະລິດຕະພາບ ແລະ ຜົນຜະລິດສາລີ ແມ່ນໄດ້ເພີ້ມຂຶ້ນຢ່າງວ່ອງ ໄວ, ຕາມຂໍ້ມູນສະຖິຕິ ຂອງ ກົມປູກຝັງ (ກະຊວງ ກະສິກຳ ແລະ ປ່າໄມ້) ປີ 2007, ລວມຍອດຜົນຜະ ລິດສາລີ ຂອງລາວ ແມ່ນໄດ້ເພີ້ມຂຶ້ນ 620,550 ໂຕນ, ຜະລິດຕະພາບ ສະເລ່ຍ 4.68 ໂຕນ/ຮຕ. ເພື່ອຕອບສະໜອງ ການຜະລິດ ໃນແຕ່ລະປີ ໃຫ້ ນັບມື້ຫຼາຍຂຶ້ນ, ບັນຫາທີ່ສຳຄັນ ແມ່ນແນວພັນປູກ ຕ້ອງໄດ້ມີການຄົ້ນຄວ້າ ທົດລອງ ແລະ ຄັດ ເລືອກ ເປັນປະຈຳ ເພື່ອໃຫ້ໄດ້ແນວພັນທີ່ດີ ມີ ຄຸນນະພາບ, ໃຫ້ຜົນຜະລິດສູງ ແລະ ແທດເໝາະ ກັບເງື່ອນໄຂສະພາບແວດລ້ອມ ຂອງ ທ້ອງຖິ່ນ.

ສຳລັບ ແນວພັນສາລີລູກປະສົມ ທີ່ຊາວ ກະສິກອນປູກໃນປັດຈຸບັນ ແມ່ນນຳເຂົ້າຈາກຕ່າງ ປະເທດ, ເຊິ່ງເປັນບັນຫາຫຍຸ້ງຍາກໃຫ້ແກ່ເຂົາ ເຈົ້າ ໃນການປູກສາລີ ແຕ່ລະປີ, ຍ້ອນແນວພັນ ບໍ່ໄດ້ຄຸນນະພາບ, ບໍ່ທັນກັບລະດູການ ແລະ ມີ ລາຄາແພງ ເຮັດໃຫ້ສິ້ນເປືອງຕົ້ນທຶນ ການຜະລິດ ສະນັ້ນ ເພື່ອຕອບສະໜອງແນວພັນ ໃຫ້ມີຄຸນນະ ພາບ ແລະ ທັນກັບລະດູການ, ຈຶ່ງໄດ້ທົດລອງ ສົມທຽບສາຍພັນ ແລະ ແນວພັນສາລີໃໝ່ ເພື່ອ ຮັບໃຊ້ໃຫ້ແກ່ການຜະລິດ ຢູ່ທົ່ງພຽງວຽງຈັນ ກໍ່ຄື ໃນທົ່ວປະເທດ.

II. ອຸປະກອນ ແລະ ວິທີການ

2.1 ອຸປະກອນ

- ລະດູທີ 1: ລະດູຝົນ ລວມມີ 3 ສາຍ ພັນ, 9 ແນວພັນ ຈາກ ວຽດນາມ ແລະ ໄທ ຄື: 3106x33338, 3150x3220, 324x3115, LVN61, LVN99, LVN45, LVN10, KK575, 8960, H06-2, Se161171 ແລະ CP888.
- ລະດູທີ 2: ລະດູແລ້ງ ລວມມີ 7 ສາຍ ພັນ ຈາກ ວຽດນາມ ແລະ ໄທ ຄື: 3335x3186, 3249x3172, 3375x3363, R7xT1, P7XT2, R8XT3, R7Xr3, LVN61, LVN99, LVN45, LVN10, KK575, LVN25 ແລະ CP888.
- ສາຍພັນ ແມ່ນໄດ້ຈາກ ສາລີຄູ່ປະສົມ ຂອງບົດວິທະຍານິພົນ ຄົ້ນຄວ້າສາລີ, ສ່ວນແນວພັນສາລີ ແມ່ນ ສະຖາບັນ ຄົ້ນຄວ້າສາລີ ແລະ ໂຮງຮຽນ ກະສິກຳ ຮ່າໂນ້ຍ ສ.ສ ວຽດນາມ ສະໜອງໃຫ້ ເພື່ອປູກທົດລອງສົມທຽບ (ແນວພັນ LVN10 ແລະ CP888 ເປັນຕົວຢືນ).

2.2 ວິທີການ

ການທົດລອງ ແມ່ນໄດ້ປະຕິບັດ ໃນ 2 ລະດູ ຄື: ລະດູຝົນ ແລະ ລະດູແລ້ງ ປີ 2007.

ກ. ສະຖານທີ່ທົດລອງ

ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ ນາພອກ. ການວາງແປງແບບ RCB ມີ 3 ຊ້ຳ, ເນື້ອທີ່ແປງແມ່ນ 14 $ม^2$ ໄລຍະຫ່າງ ລະຫວ່າງ ແຖວ 70 ຊຕມ, ໄລຍະຫ່າງ ລະຫວ່າງ ຕົ້ນ 25 ຊຕມ, ສະເລ່ຍ 57,000 ຕົ້ນ/ຮຕ.

ຂ. ສະຖານທີ່ທົດລອງ

ເປັນດິນຕົມແກມຊາຍ (SL), ປະຕິກິລິຍາ ຄວາມເປັນກົດສູງ (pH) = 4,78-5,27, ປະລິ ມານສານອິນຊີວັດຖຸ (P_2O_5) = 15,15–15,60 ແລະ ທາດໂປຕັດຊຽມ (K_2O)=4,8–5,6. (ເນື້ອ ໄຈດິນ ຈາກ ສູນຄົ້ນຄວ້າ ກະສິກຳ ແລະ ພືດ ເສດຖະກິດ).

ຄ. ອັດຕາຝຸ່ນ

ຝຸ່ນຄອກ 10 ໂຕນ/ຮຕ, ໃສ່ຝຸ່ນເລັ່ງ ດ້ວຍຝຸ່ນວິທະຍາສາດ $150N + 60P_2O_5 + 60 K_2O$.

ງ. ການໃສ່ຝຸ່ນ

- ຝຸ່ນຄອກ ແລະ ຝຸ່ນເຄມີ P_2O_5 ປະສົມ ເຂົ້າກັນ ໃສ່ຮອງພື້ນທັງໝົດ ກ່ອນປູກ.
- ໃສ່ຝຸ່ນເລັ່ງ ຄັ້ງທີ 1: ຫຼັງປູກສາລີ ໄດ້ 3-4 ໃບ = $1/3 N + 1/3 K_2O$.
- ໃສ່ຝຸ່ນເລັ່ງ ຄັ້ງທີ 2: ຫຼັງປູກສາລີ ໄດ້ 8-9 ໃບ = $1/3N + 1/3K_2O$.
- ໃສ່ຝຸ່ນເລັ່ງ ຄັ້ງທີ 3: ກ່ອນສາລີຈະ ອອກ 10 - 15 ວັນ ແມ່ນໃສ່ໝົດ ຈຳນວນຝຸ່ນທີ່ເຫຼືອ.
- ຄິດໄລ່ຂໍ້ມູນດ້ວຍລະບົບ IRRISTAT version 3.1

III. ຜົນໄດ້ຮັບ ຂອງ ການທົດລອງ

ຜ່ານການທົດລອງ ເຫັນວ່າ ການຈະເລີນ ເຕີບໂຕ ແລະ ຜົນຜະລິດ ຂອງ ແນວພັນ, ສາຍ ພັນສາລີ ໃນ 2 ລະດູການ ແມ່ນໃຫ້ຜົນຜະລິດ ດີສົມຄວນ (ຕາຕະລາງ ທີ 1).

ລະດູຝົນ ການຈະເລີນເຕີບໂຕ ຂອງ ແນວພັນ ແລະ ສາຍພັນສາລີ ນັບແຕ່ປູກຫາ ອອກດອກ ປະສົມພັນ ແມ່ນໃຊ້ເວລາ 61-68 ວັນ, ໃນນີ້ ແນວພັນ Se-161171 ປະສົມພັນ ຊ້າກວ່າໝູ່ 68 ວັນ, ແນວພັນ LVN61, LVN99 ແລະ ສາຍພັນ 3150x3220 ແຕ່ປູກ ຫາ ອອກດອກ ປະສົມພັນໄວກວ່າໝູ່ 61 ວັນ, ອາຍຸແຕ່ປູກ ຫາເກັບກູ້ ຂອງແນວພັນ, ສາຍພັນ ສາລີ ແມ່ນມີ ອາຍຸແຕ່ 115 – 126 ວັນ, ໃນນີ້ ສາຍພັນ 3150x3220, 3204x3115, ອາຍຸແຕ່ປູກ ຫາເກັບກູ້ ສັ້ນກວ່າໝູ່ 115 ວັນ, ທຽບໃສ່ບັນດາແນວພັນອື່ນ ແມ່ນມີອາຍຸຍາວກວ່າ ແຕ່ 117 – 126 ວັນ.

ລະດູແລ້ງ ຜ່ານການທົດລອງ ແນວພັນ ແລະ ສາຍພັນສາລີ, ແຕ່ປູກຫາອອກດອກປະສົມ ພັນ ໃຊ້ເວລາ 65 - 71 ວັນ, ແນວພັນ CP888 ອອກດອກປະສົມພັນ ຊ້າກວ່າໝູ່ 71 ວັນ, ສາຍ ພັນ R7xT2, R8xT3, R8xT3, 3375x3363 ແຕ່ປູກ ຫາອອກດອກປະສົມພັນໄວກ່ວາ 63 ວັນ ບັນດາແນວພັນ, ສາຍພັນສາລີ ມີອາຍຸ ແຕ່ປູກ ຫາເກັບກູ້ແຕ່ 115 – 129 ວັນ ແລະ ແນວພັນ CP888 ມີອາຍຸແຕ່ປູກຫາເກັບກູ້ ຍາວກວ່າໝູ່ 129 ວັນ, ສາຍພັນ R7xT2, R8xT3, R7xT6, 3375x3363 ມີອາຍຸແຕ່ ປູກຫາເກັບກູ້ສັ້ນກວ່າ ບັນດາແນວພັນສາລີ ທົດລອງ 115 ວັນ.

ຕາຕະລາງ 1: **ການຈະເລີນເຕີບໂຕ ຂອງແນວພັນ ແລະ ສາຍພັນສາລີ ໃນລະດູແລ້ງ ແລະ ລະດູຝົນ ທີ່ ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ (ນາພອກ) ປີ 2007.**

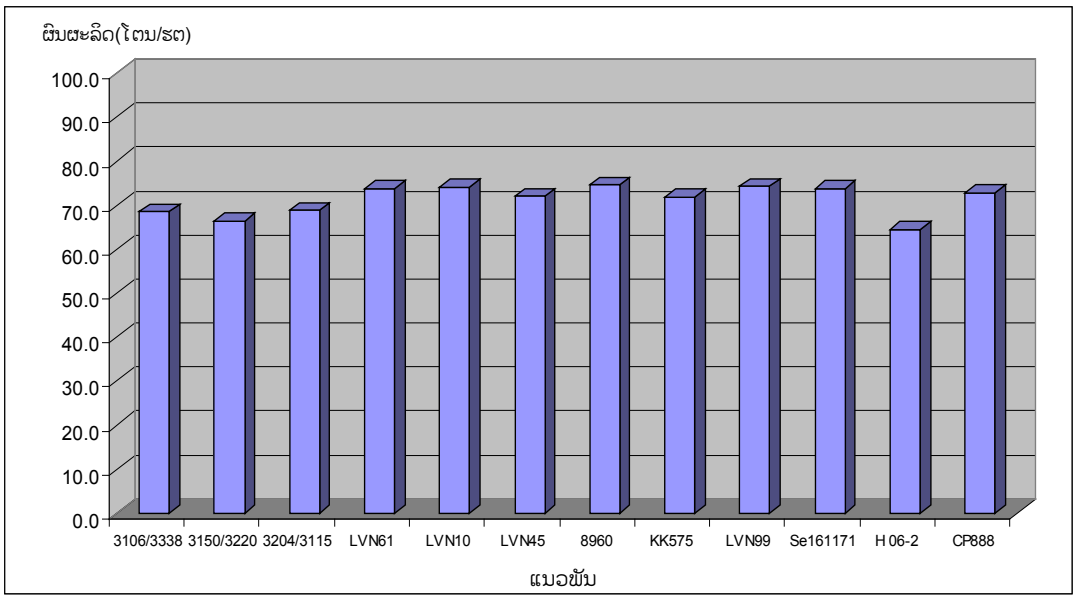
ລ/ດ	ແນວພັນ / ສາຍພັນ	ລະດູແລ້ງ			ລ/ດ	ລະດູຝົນ		
		ອາຍຸອອກດອກຜູ້ (ວັນ)	ອາຍຸອອກດອກແມ່ (ວັນ)	ອາຍຸເກັບກ່ຽວ (ວັນ)		ອາຍຸອອກດອກຜູ້ (ວັນ)	ອາຍຸອອກດອກແມ່ (ວັນ)	ອາຍຸເກັບກ່ຽວ (ວັນ)
1	LVN10	62	64	124	LVN10	64	66	124
2	3106x3338	61	63	117	R7xT7	64	66	124
3	3150x3220	59	61	115	R7xT2	61	63	115
4	3204x3115	60	62	115	R8xT3	61	63	115
5	LVN61	59	61	118	R7xR6	61	63	115
6	LVN45	64	66	117	3335x3186	64	66	124
7	8960	64	66	117	3249x3172	64	66	124
8	KK575	63	65	120	3375x3363	61	63	115
9	LVN99	59	61	117	LVN25	63	65	121
10	Se161171	65	68	126	KK575	64	66	124
11	H-06-2	61	63	120	LVN99	63	65	121
12	CP888	64	66	117	LVN45	64	66	124
13					LVN61	64	65	121
14					8960	64	66	124
15					CP888	68	71	129

3.1 ສະມັດຕະພາບ ແລະ ຜົນຜະລິດ ຂອງ ແນວພັນສາລີ ໃນລະດູຝົນ

ໃນຕາຕະລາງ ທີ 2 ແລະ ເສັ້ນສະແດງ ທີ 1: ລະດູຝົນ ລວງຍາວຂອງມານ ຂອງແນວພັນ, ສາຍພັນສາລີ ມີຄວາມແຕກຕ່າງກັນ ແຕ່ 16.6-19.3 ຊຕມ. ບັນດາແນວພັນ ລ້ວນແຕ່ມີລວງ ຍາວມານ ສູງກວ່າ ບັນດາສາຍພັນ, ໃນນີ້ ແນວ ພັນ LVN45 ມີລວງຍາວມານ ສູງກວ່າໝູ່ 19.3 ຊຕມ ແລະ ສາຍພັນ 3150x3220 ມີລວງຍາວ ມານ ນ້ອຍກວ່າໝູ່ 16.6 ຊຕມ, ລວງກວ້າງມານ ຂອງແນວພັນ, ສາຍພັນສາລີ ແມ່ນມີລວງກວ້າງ ແຕ່ 4.2-5.0 ຊຕມ. ແນວພັນ LVN61 ມີລວງ ກວ້າງມານ ສູງກວ່າໝູ່ 5.0 ຊຕມ ແລະ ແນວພັນ LVN10, CP888 ມີລວງກວ້າງມານ ນ້ອຍກວ່າ ໝູ່ 4.4 ຊຕມ, ຈຳນວນໜ່ວຍ ແກ່ນ/ມານ ແມ່ນ ມີແຕ່ 12.1-16.6 ແຖວແກ່ນ/ມານ ໃນນີ້ ສາຍ ພັນ 3106x3338 ມີຈຳນວນແຖວແກ່ນ/ມານ ສູງກວ່າໝູ່ 16.6 ແຖວ ແລະ ແນວພັນ CP888 ມີຈຳນວນແຖວແກ່ນ/ມານ ນ້ອຍກວ່າໝູ່ 12.1 ແຖວ/ມານ, ຈຳນວນແກ່ນ/ແຖວ ກໍ່ຄ້າຍຄືກັບ ແນວພັນ LVN45 ມີຈຳນວນແກ່ນ/ແຖວ ສູງກວ່າ ໝູ່ 41.1 ແກ່ນ/ແຖວ, ແນວພັນ Se-161171 ມີຈຳນວນແກ່ນ/ແຖວ ຕ່ຳກວ່າໝູ່ 35.4 ແກ່ນ/ ແຖວ, ໃນນີ້ ແນວພັນ LVN61, LVN10, LVN99 ໃຫ້ຜົນຜະລິດສູງກວ່າໝູ່ ແຕ່ 7.36-7.41 ໂຕນ/ຮຕ, ທຽບໃສ່ຜົນຜະລິດ ຂອງສາຍ ພັນ ແມ່ນຕ່ຳກວ່າ ແຕ່ 6.62–6.94 ໂຕນ/ຮຕ.

ຕາຕະລາງ 2: ຜົນຜະລິດ ຂອງແນວພັນ ແລະ ສາຍພັນສາລີ ໃນລະດູຝົນ ທີ່ ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ (ນາພອກ) ປີ 2007.

ລ/ດ	ແນວພັນ / ສາຍພັນ	ລວງຍາວ ມານ (cm)	ລວງກວ້າງ ມານ (cm)	ຈຳນວນ ແຖວ/ມານ	ຈຳນວນ ແກ່ນ/ມານ	ນ້ຳໜັກ 1000 ເມັດ (ກຼາມ)	ຜົນຜະລິດ (ໂຕ/ຮຕ)
1	LVN- 10	17.5	4.3	12.9	37.0	317.4	7.38
2	3106x3338	17.2	4.9	16.6	36.9	293.2	6.85
3	3150x3220	16.6	4.8	15.2	36.5	284.0	6.62
4	3204x3115	17.3	4.9	15.1	38.7	273.3	6.94
5	LVN - 61	17.5	5.0	15.6	38.2	326.6	7.36
6	LVN - 45	19.3	4.7	12.6	41.1	333.3	7.19
7	8960	18.3	4.5	13.7	39.1	326.6	7.28
8	KK575	18.1	4.6	14.1	36.4	320.0	7.17
9	LVN99	18.4	4.4	14.9	37.8	342.2	7.41
10	Se -161171	18.0	4.5	14.0	35.4	306.6	7.36
11	H-06-2	17.8	4.6	15.9	37.4	293.4	6.43
12	CP888	17.8	4.2	12.1	38.8	299.2	7.27
	CV%	**1.8**	**1.1**	**2.5**	**2.0**		**6.6**
	LSD 0.05						**8.0**



ຮູບສະແດງ ທີ 1: ຜົນຜະລິດ ຂອງແນວພັນ ແລະ ສາຍພັນສາລີ ໃນລະດູຝົນ ທີ່ ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ (ນາພອກ) ປີ 2007.

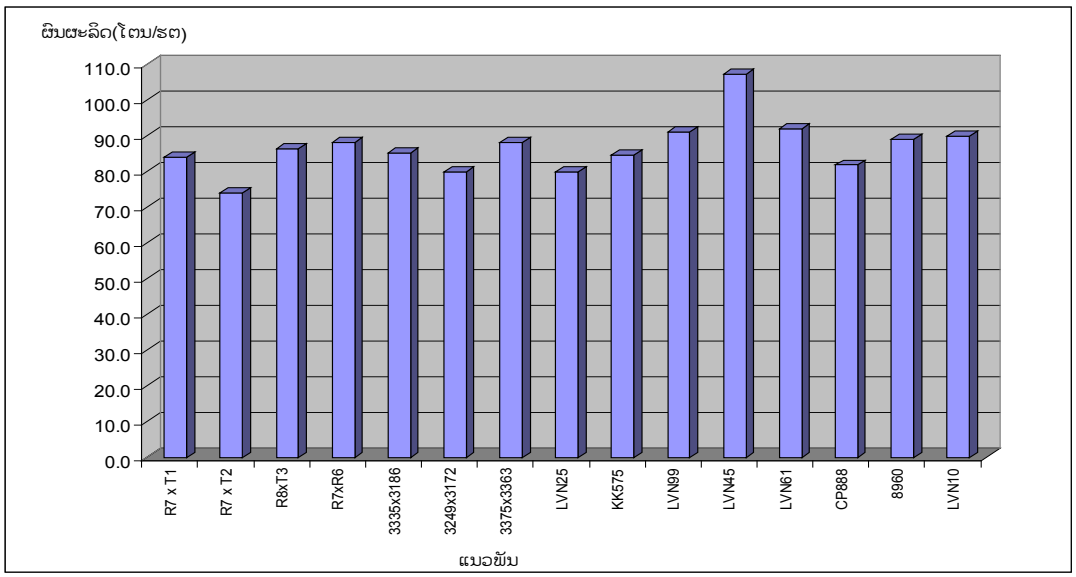
3.2 ສະມັດຕະພາບ ແລະ ຜົນຜະລິດ ຂອງ ແນວພັນສາລີ ໃນລະດູແລ້ງ

ຕາມຂໍ້ມູນ ຢູ່ ຕາຕະລາງ ທີ 3 ແລະ ເສັ້ນສະແດງ ທີ 2: ເຫັນວ່າ ລວງຍາວ ຂອງ ມານ ຄື ແນວພັນ, ສາຍພັນສາລີ ລະດູແລ້ງ ມີ ລວງຍາວມານ ແຕ່ 16.1-20.5 ຊຕມ ໃນນີ້ ແນວພັນ LVN45 ມີລວງຍາວມານ ສູງກວ່າໝູ່ 20.5 ຊຕມ, ແນວພັນ LVN25 ແລະ ສາຍພັນ R7xT2 ມີລວງຍາວມານ ນ້ອຍກວ່າໝູ່ 16.1 ຊຕມ, ສາຍພັນ 3335x3186 ມີລວງກວ້າງມານ ສູງກວ່າໝູ່ 5.2 ຊຕມ. ແນວພັນ LVN10, CP888 ມີລວງກວ້າງມານ ຕ່ຳກ່ວາໝູ່ 4.4 ຊຕມ, ຈຳນວນແຖວແກ່ນ/ມານ ຂອງແນວພັນ, ສາຍພັນສາລີ ແມ່ນມີແຕ່ 11.9-16.2 ແຖວ/ ມານ. ແນວພັນ LVN25 ມີຈຳນວນແຖວແກ່ນ/ ມານ ສູງກ່ວາໝູ່ 16,2 ແຖວ/ມານ ແລະ ແນວພັນ CP888, ມີຈຳນວນແຖວແກ່ນ/ມານ ໜ້ອຍກວ່າ ໝູ່ 11.9 ແຖວ/ມານ, ທຽບໃສ່ສາຍພັນແມ່ນມີ ຈຳນວນແຖວແກ່ນ/ມານ ແຕ່ 12.4-15.2 ແຖວ ແກ່ນ/ມານ, ຈຳນວນແກ່ນ/ແຖວ ຂອງແນວພັນ ແລະ ສາຍພັນສາລີ ແມ່ນມີແຕ່ 33.3-44.0 ແກ່ນ/ແຖວ. ສາຍພັນ 3375 x 3363 ແລະ ແນວພັນ LVN45 ມີຈຳນວນແກ່ນ/ແຖວ ສູງກວ່າ ໝູ່ 43.0-44,0 ແກ່ນ/ແຖວ ແລະ ແນວພັນ LVN25 ມີຈຳນວນແກ່ນ/ແຖວ ໜ້ອຍກວ່າໝູ່ 33.3 ແກ່ນ/ແຖວ, ຜົນຜະລິດຂອງແນວພັນ, ສາຍພັນສາລີ ໃນລະດູແລ້ງ ເຫັນວ່າ ໃຫ້ຜົນຜະ ລິດສູງກວ່າລະດູຝົນ, ຖ້າປູກຖືກລະດູການ ແລະ ຕອບສະໜອງນ້ຳໃຫ້ພຽງພໍ, ເພາະວ່າ ສາລີ ໃນ

ລະດູແລ້ງ ໃນຊ່ວງສາລີອອກດອກ ປະສົມພັນ ມີອຸນຫະພູມທີ່ເໝາະສົມ, ບໍ່ມີຝົນຫຼາຍ ແລະ ມີ ລົມແຮງຄືລະດູຝົນ ເຊິ່ງເປັນເງື່ອນໄຂອັນດີ ໃຫ້ ແກ່ການອອກດອກປະສົມພັນ ຂອງສາລີ, ຜ່ານ ການທົດລອງເຫັນວ່າ ຜົນຜະລິດຂອງແມ່ພັນ ແລະ ສາຍພັນສາລີ ໃນລະດູແລ້ງ ໃຫ້ຜົນຜະລິດດີ ແຕ່ 7.39 - 10.07 ໂຕນ/ຮຕ ໃນນີ້ ແມ່ພັນ LVN45 ໃຫ້ຜົນຜະລິດ ສູງກວ່າໝູ່ 10.07 ໂຕນ/ຮຕ, ທຽບໃສ່ບັນດາສາຍພັນ R8xT3, 3204x3115, R7xR7xR6 ຜົນຜະລິດ 8.62-8.81 ໂຕນ/ຮຕ ສູງກວ່າແມ່ພັນ LVN25, KK575 ແລະ CP888 ແລະ ສາຍພັນ R7xT2 ໃຫ້ຜົນຜະລິດຕ່ຳກວ່າໝູ່ 7.39 ຕ/ຮຕ.

ຕາຕະລາງ 3: ຜົນຜະລິດ ຂອງແມ່ພັນ ແລະ ສາຍພັນສາລີ ໃນລະດູແລ້ງ ທີ່ ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ (ນາພອກ) ປີ 2007.

ລ/ດ	ແມ່ພັນ / ສາຍພັນ	ລວງຍາວ ມານ (ຊຕມ)	ລວງກ້ວາງ ມານ (ຊຕມ)	ຈ/ນ ແຖວ ແກ່ນ/ມານ	ຈຳນວນ ແກ່ນ/ແຖວ	ນ້ຳໜັກ 1,000 ເມັດ (ກຼາມ)	ຜົນຜະລິດ (ຕ/ຮຕ)
1	LVN-10	18.1	4.4	12.3	39.4	360.0	8.97
2	R7xT1	18.1	4.8	12.2	36.9	393.2	8.39
3	R7xT2	16.1	4.8	13.5	34.1	386.6	7.39
4	R8xT3	17.6	4.9	12.6	38.1	393.2	8.62
5	R7xR6	17.8	4.9	14.0	38.6	380.0	8.81
6	3335x3186	17.5	5.2	15.2	37.0	386.6	8.49
7	3249x3172	17.3	4.9	14.8	37.6	350.0	7.99
8	3375x3363	18.8	4.5	12.4	43.0	345.0	8.79
9	LNN - 25	16.1	5.1	16.2	33.3	356.6	7.97
1	KK 575	17.7	4.9	14.2	37.3	376.6	8.46
11	LVN - 99	18.3	4.6	14.2	40.8	353.3	9.09
12	LVN - 45	20.5	5.0	12.7	44.0	400.0	10.07
13	LVN - 61	17.9	5.1	15.0	38.9	360.0	9.17
14	8960	18.2	4.6	13.5	39.1	360.0	8.89
15	CP888	18.3	4.4	11.9	39.7	350.0	8.17
	CV%	**3.2**	**2.0**	**2.3**	**3.0**		**6.8**
	LSD 0.05						**9.8**



ຮູບສະແດງ ທີ 2: ຜົນຜະລິດ ຂອງແນວພັນ ແລະ ສາຍພັນສາລີ ໃນລະດູແລ້ງ ທີ່ ສູນຄົ້ນຄວ້າເຂົ້າ ແລະ ພືດເສດຖະກິດ (ນາພອກ) ປີ 2007.

ຮູບສະແດງ ທີ 3: ແນວພັນ ສາລີ LVN61 ຈາກ ສສ ວຽດນາມ.

IV. ຜົນໄດ້ຮັບ

ຜ່ານການທົດລອງ ສົມທຽບ ການຄັດເລືອກແນວພັນ ແລະ ສາຍພັນສາລີ ໃນ 2 ລະດູ ເຫັນວ່າ ມີຫຼາຍແນວພັນ ແລະ ສາຍພັນສາລີ ໃຫ້ຜົນຜະລິດສູງ ແລະ ເໝາະສົມ ກັບສະພາບ ແວດລ້ອມ ຢູ່ໃນທົ່ງພຽງວຽງຈັນ ກໍ່ຄື ໃນທົ່ວປະເທດ.

ລະດູຝົນ ມີ 3 ແນວພັນ ໃຫ້ຜົນຜະລິດ ສູງ ຄື: 8960, LVN61, LVN99 ໃຫ້ຜົນຜະລິດ ແຕ່ 7.28-7.41 ໂຕນ/ຮຕ ແລະ ມີອາຍຸແຕ່ 115-124 ວັນ.

ລະດູແລ້ງ ມີ 5 ສາຍພັນ ໃຫ້ຜົນຜະລິດ ດີ ຄື: R8xT3, R7xR6, R7xT1, 3106x3338, 3375x3363. ໃຫ້ຜົນຜະລິດ ແຕ່ 8.39-8.81 ໂຕນ/ຮຕ ແລະ ມີອາຍຸ ແຕ່ 115-124 ວັນ, ມີ 5 ແນວພັນ ໃຫ້ຜົນຜະລິດສູງ ສະໝ່ຳສະເໝີ ໃນ 2 ລະດູ ຜ່ານມາ ຄື: 8960, LVN10, LVN61, LVN99, LVN45, ໃຫ້ຜົນຜະລິດ ແຕ່ 8.89-10.07 ໂຕນ/ຮຕ ແລະ ມີອາຍຸແຕ່ 117-124 ວັນ ເຊິ່ງສາມາດນຳໄປເພາະປູກໄດ້ ຢູ່ ໃນ ສປປ ລາວ.

V. ເອກະສານອ້າງອີງ

ໂງທິວຕ່ຳ, ສາລີ, ຫຼັກສູດສິດສອນ ປະລິນຍາໂທ ກະສິກຳ, ໂຮງພິມກະສິກຳ ຮ່າໂน้ย 1997.

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