ORIGINAL ARTICLE

Evaluation of seven peanut genotypes for nitrogen fixation and agronomic traits

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Abstract

Pimratch, S., Jogloy, S., Toomsan, B., Jaisil, P., Sikhinarum, J., Kesmala, T. and Patanothai, A.
Evaluation of seven peanut genotypes for nitrogen fixation and agronomic traits
Songklanakarin J. Sci. Technol., 2004, 26(3) : 295-304

Indirect measurement of the traits related to N_2-fixation may be useful as selection criteria for high nitrogen fixation. The objectives of this study were to determine the association between parameters indicative of nitrogen fixation and agronomic traits and to identify peanut genotypes with good nitrogen fixing ability and agronomic traits. Seven peanut genotypes were planted in a randomized complete block design with 4 replications under rainfed conditions in 2001 and 2002. Nitrogen fixation parameters were recorded as leaf color score, nodule dry weight, shoot dry weight, total dry weight, total nitrogen and fixed nitrogen while agronomic data were recorded as pod number per plant, pod weight per plant, seed number per plant, seed number per pod, seed weight per plant, 100-seed weight, shelling percentage and harvest index.

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Received, 2 October 2003 Accepted, 23 December 2003

Difference between years was significant for most traits except for shoot dry weight and 100-seed weight. Variety x year interactions were also significant for most traits except for shelling percentage. KKU 72-1 was the best genotypes for nitrogen fixation parameters in 2001. KKU 1 did not perform well in nitrogen fixation traits, but did for most agronomic traits, especially in 2002 except for 100-seed weight. Leaf color score and shoot dry weight may be useful as alternative means for determining nitrogen fixing ability of peanut under field evaluation. High association among nitrogen fixation parameters were found in both years. However, correlations between nitrogen fixation parameters and agronomic traits were not strong in 2002.

Key words : *Arachis hypogaea* L., symbiotic nitrogen fixation, agronomic traits

บทคัดย่อ

สำราญ พิมราช สนั่น จอกลอย บรรยง ทุมแสน ประสิทธิ์ ใจศิล จำรูญ สิขินารัมย์ ถวัลย์ เกษมาลา และ อารันต์ พัฒโนทัย

การประเมินการตรึงไนโตรเจนและลักษณะทางการเกษตรของถั่วลิสง 7 พันธุ์

ว. สงขลานครินทร์ วทท. 2546 26(3) : 295-304

ลักษณะที่มีความสัมพันธ์กับการตรึงไนโตรเจน อาจนำมาใช้เป็นเกณฑ์ในการคัดเลือกพันธุ์ถั่วลิสงที่มีความสามารถในการตรึงไนโตรเจนสูงได้ การทดลองนี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ของลักษณะการตรึงไนโตรเจนและลักษณะทางการเกษตรและระบุพันธุ์ที่มีความสามารถในการตรึงไนโตรเจนและลักษณะทางการเกษตรดี โดยประเมินถั่วลิสง 7 พันธุ์ ใช้แผนการทดลองแบบสุ่มสมบูรณ์ภายในซ้ำ มี 4 ซ้ำ ในปีพ.ศ. 2544 และ 2545 สำหรับลักษณะการตรึงไนโตรเจนบันทึกลักษณะคะแนนสีใบ น้ำหนักปมแห้ง น้ำหนักต้นแห้ง น้ำหนักแห้งทั้งหมด ปริมาณไนโตรเจนทั้งหมด และปริมาณไนโตรเจนที่ตรึงได้ต่อต้น และลักษณะทางการเกษตรบันทึกลักษณะจำนวนฝัก/ต้น น้ำหนักฝัก/ต้น จำนวนเมล็ด/ต้น จำนวนเมล็ด/ฝัก น้ำหนักเมล็ด/ต้น น้ำหนัก 100 เมล็ด เปอร์เซ็นต์กะเทาะ และดัชนีเก็บเกี่ยว ผลการทดลองพบว่าความแตกต่างระหว่างปีมีนัยสำคัญทางสถิติในเกือบทุกลักษณะยกเว้นลักษณะน้ำหนักต้นแห้งและน้ำหนัก 100 เมล็ด ปฏิสัมพันธ์ระหว่างพันธุ์และปีมีนัยสำคัญทางสถิติในเกือบทุกลักษณะยกเว้นลักษณะเปอร์เซ็นต์กะเทาะ พันธุ์ KKU 72-1 มีลักษณะการตรึงไนโตรเจนสูงในปีพ.ศ. 2544 พันธุ์ KKU 1 มีลักษณะการตรึงไนโตรเจนต่ำแต่มีลักษณะทางการเกษตรดีในปีพ.ศ. 2545 ยกเว้นลักษณะน้ำหนัก 100 เมล็ด การใช้คะแนนสีใบและน้ำหนักต้นแห้งอาจเป็นวิธีที่เหมาะสมในการประเมินในสภาพไร่ การวิเคราะห์ค่าสัมประสิทธิ์สหสัมพันธ์พบว่าลักษณะการตรึงไนโตรเจนมีสหสัมพันธ์กันสูงทั้งในปีพ.ศ. 2544 และ 2545 แต่ค่าสัมประสิทธิ์สหสัมพันธ์ระหว่างลักษณะการตรึงไนโตรเจนและลักษณะทางการเกษตรในปีพ.ศ. 2545 ต่ำกว่าในปี 2544

ภาควิชาพืชไร่ คณะเกษตรศาสตร์ มหาวิทยาลัยขอนแก่น อำเภอเมือง จังหวัดขอนแก่น 40002

Peanut (*Arachis hypogaea* L.) is one of the leguminous crops that can produce root nodules and can fix atmospheric nitrogen by symbiotic relationship with cowpea-type rhizobium which predominate in tropical soils (Toomsan *et al.*, 1991). Nitrogen fixing ability in peanut varies widely, depending on peanut genotypes (Nambiar and Dart, 1983) and rhizobium strains (Wynne *et al.*, 1980). Peanuts fixing nitrogen at the amount of 12-15 kg rai^{-1} (0.16 ha) $year^{-1}$ has been reported (FAO, 1984). Kuccy and Toomsan (1988) reported that peanut cultivars: Tainan 9, Moket (presently KK 60-1), and KAC 431; fixed nitrogen at amount of 6.0, 6.5 and 9.6 kg rai^{-1} $year^{-1}$, respectively. Symbiotic nitrogen fixation is important for growth and yield of leguminous crops especially in infertile soils; and nitrogen from the peanut residues is beneficial for following crops such as rice, cassava, sugarcane and field maize. This provides a sustainable means for crop production and enhancing crop productivity in semi-arid tropic regions, including in the Northeast Thailand, which were characterized by low soil fertility and unpredictable rainfalls.

Peanut genotypes with high nitrogen fixing ability usually have high vegetative growth and low yielding ability. Therefore, the incorporation of high N_2-fixation trait into peanut cultivars with high yielding potential is important. This study was conducted to determine the association between parameters indicative of nitrogen fixation and agronomic traits and to identify peanut genotypes with high nitrogen fixing ability and agronomic traits.

Materials and Methods

Plant materials and experimental procedures

Six peanut genotypes being potentially useful as germplasm source for high yielding and nitrogen fixing ability were selected for the study. These were A3-1-1 (Bc 145) (PI 268770), 42-G-105 (PI 269109), Virginia Bunch (PI 152133), KKU 1, KKU 72-1 and KK60-3. A3-1-1 (Bc 145) (PI 268770), 42-G-105 (PI 269109) and Virginia Bunch (PI 152133) were selected because of high nitrogen fixing ability from preliminary evaluation under greenhouse conditions (Toomsan *et al.*, 1991), and hereafter designated as PI 268770, PI 269109 and PI 152133, respectively. KKU 1 is Spanish-type while KKU 72-1 is a Virginia-type released cultivar in Thailand by Khon Kaen University and KK 60-3 is a Virginia-type released cultivar in Thailand by the Department of Agriculture, Ministry of Agriculture and Cooperatives. A non-nodulating line (referred to as nonnod) was also used as a reference plant.

The experiment was conducted at Khon - Kaen University's agronomy farm during June to November in 2001 and 2002. A randomized complete block design with 4 replications was used in both years. The experimental plots were 3 m long and 2 m wide with spacings of 50 cm between rows and 30 cm between plants within row. During soil preparation, lime (CaO) was incorporated into soil at the rate of 100 kg rai^{-1} (0.16 ha). Seeds were treated with fungicide (Captan) at the rate of 10 g kg^{-1}. No rhizobium inoculation was used because the experimental sites had the history of peanut cultivation in previous years and peanut crops did not respond to rhizobium inoculation (Toomsan *et al.*, 1988). Pre-emergence herbicide (Alachlor) was spayed soon after planting to control weeds. Gap filling was done at 7 days after planting for both years because of poor germination. Inorganic fertilizers at the rate of 0-9-6 kg rai^{-1} for N-P_2O_5 and K_2O were applied at 21 days after planting. Standard cultural practices were followed, including hand weeding at 21 days after planting and application of gypsum ($CaSO_4$) at rate of 50 kg rai^{-1} at peak flowering (35 days after planting). Fungicides, pesticides and irrigation were applied as crop need.

Data collection

Leaf color score, rating 1 to 4 where 1= pale yellow and 4= dark green, was recorded for each plot at 50 days after planting (Srisaowakonthorn, 1989; Phudenpa, 2002). At harvest, plants at the 2 ends of the rows were discarded and samples were taken from the remainder. Number of harvested plants was recorded for each plot. The samples in each plot were separated into parts. Nodules, stems and leaves were oven-dried at 80^{o} C for 48 hr and nodule dry weight, shoot dry weight and total dry weight were determined. Pods were air-dried to obtain approximately 8% moisture content and shelled. Then, pod number per plant, seed number per plant, pod weight per plant, seed weight per plant, 100-seed weight, shelling percentage and harvest index were determined.

To measure nitrogen fixation, samples were ground and crude protein content was obtained using micro-Kjeldahl method (Black, 1965). Nitrogen content was measured by automated indophenol method (Schuman *et al.*, 1973) and were read on flow injection analyzer (FIA), model 5012 ANALYZER, TECATOR 5207.

The amount of fixed nitrogen was calculated as the difference between total nitrogen content and taken up nitrogen content based on the assumption that the fixing cultivars took up the same amount of soil nitrogen as the non-fixing one while the remainder was fixed.

Total fixed N = Total N of each genotype - Total N of nonnod

Data analysis

Peanut genotypes were deliberately chosen and considered as fixed effects, while replications and years were random. Analysis of variance was performed for each trait to test significant differences among peanut genotypes and Duncan's multiple range test (DMRT) was used to compared means. Pairs of error mean squares for each trait were tested for variance heterogeneity by Bartlett's method (Gomez and Gomez, 1984) Error variances were not significantly different by F-test. Therefore, combined analysis of variance was performed.

Phenotypic correlation coefficients among nitrogen fixation parameters and agronomic traits were calculated based on plot means, using correlation function of MSTAT-C (Bricker, 1989).

Results and Discussion

Combined analysis of variance of two year data showed that differences between years were significant for most traits except for shoot dry weight and 100-seed weight. Variety differences were observed for all traits and variety x year (V × Y) interactions were significant for most traits except for shelling percentage (data not shown).

The results indicated that variation of traits under study existed in the germplasm evaluated. Years and V × Y interactions were also the important sources of variation for most traits. Screening and selection of peanut genotypes for high nitrogen fixing ability and good agronomic traits may be difficult if environmental x variety interaction effects are large. Furthermore, the results indicate that multiple location testing is required.

The traits being consistent over years were considered useful as parameters indicative of nitrogen fixation and agronomic traits. Because V × Y interactions were significant for most traits, comparison of mean differences were conducted separately in two years. Data of nonnod which showed zero values for nodule weight and total N_2-fixation and 1 for leaf color score were deleted from the data sets to reduce possible variance heterogeneity, but for the rest of the traits data of nonnod were included.

Nitrogen fixation parameters

Average nodule weight was higher in 2001 than in 2002. In 2001, all Virginia-type cultivars performed better than a Spanish cultivar, KKU 1 (Table 1). In 2002, the best genotype for nodule weight was PI 268770, but it was not significantly different from KKU 72-1 and KK 60-3. Nodule weight of KKU 1 (Spanish) was higher than that of PI 15133 (Virginia) in 2002.

The best genotype for shoot dry weight in 2001 was KKU 72-1. In 2002, the best genotype was KK 60-3, but it was not significantly different from PI 269109 and KKU 72-1. Among nodulating lines, KKU 1 was the poorest performer for shoot dry weight in 2001 and PI 152133 was the poorest performer in 2002.

Among nodulating lines in 2001, KKU 72-1 was the best performer for total dry weight, whereas KKU 1 was the poorest performer, but it was better than nonnod. In 2002, KKU 72-1 was still the best genotype for total dry weight, but not significantly different from KKU 1, KK 60-3, PI 268770 and PI 269109, whereas PI 152133 was the poorest performer and not better than the nonnod.

Similar results have also been reported. Toomsan *et al*. (1991) found that KK 60-3 had the highest number and weight of nodules, stover yield, total N yield and total fixed N yield, whereas Tainan 9 (a spanish local cultivar widely grown in the Northeast) had the highest pod yield, but nitrogen fixation parameters were not comparable to those of KK 60-3 (Virginia).

Leaf color score was more consistent than

Table 1. Mean comparison of 7 peanut genotypes for N_2-fixation parameters evaluated for 2 years at Khon Kaen University's agronomy farm in 2001 and 2002.

Genotypes	Nodule weight (g/plant)[1/]	Shoot dry weight(g/plant)	Total dry weight (g/plant)	Leaf color score[1/]	Total N (mg/plant)	Total fixed N (mg/plant)[1/]
Year 2001						
PI 268 770	0.470a	53.07b	60.49b	3.91a	116.20b	86.00b
PI 269 109	0.477a	49.84b	59.10b	3.83a	105.70b	75.54b
PI 152 133	0.418ab	38.28c	49.79c	2.92b	71.04c	40.87c
KKU 1	0.334b	24.88d	29.82d	2.84b	48.37cd	24.14c
KKU 72-1	0.460a	73.82a	86.22a	4.00a	162.40a	132.20a
KK 60-3	0.418ab	55.15b	64.77b	4.00a	119.10b	88.93b
nonnod	-	21.08d	25.96e	-	30.18d	-
Mean	0.430	45.16	53.74	3.58	93.28	74.61
CV (%)	13.27	8.69	7.32	2.88	13.44	16.99
Year 2002						
PI 268 770	0.476a	46.10bc	63.83ab	3.00a	101.60a	53.91ab
PI 269 109	0.399ab	49.80ab	69.11a	2.83a	98.57a	50.90b
PI 152 133	0.284c	32.33d	43.58c	2.25b	54.93b	7.26c
KKU 1	0.376b	43.58bcd	72.54a	2.40b	68.41b	20.74c
KKU 72-1	0.388ab	47.99ab	70.24a	3.13a	103.90a	56.20ab
KK 60-3	0.398ab	58.74a	77.62a	2.90a	120.30a	72.63a
nonnod	-	34.86cd	50.41bc	-	47.67b	-
Mean	0.387	44.77	63.90	2.75	85.05	43.61
CV (%)	13.85	12.84	12.34	8.39	13.77	29.27

Means in the same column followed by the same letter are not significantly different at 0.05 probability level by DMRT.
[1/] Non nod was deleted from data set.

other nitrogen fixation parameters as the ranks of peanut genotypes in two year evaluation were not different. KKU 1 and PI 152133 were the poorest genotypes for leaf color score in both years, while the others were not significantly different from each other. Phudenpa (2002) evaluating the same materials under irrigated conditions with filter cake amendment, also found similar results. However, this trait is more subjective because it is based on visual evaluation.

KKU 72-1 was the best genotype for total nitrogen content in both years, but in 2002 KKU 72-1 was not significantly different from PI 268770, PI 269109 and KK 60-3. PI 152133 and KKU 1 were the poor genotypes for total nitrogen content in both years.

KKU 72-1 was also the best genotype for total fixed nitrogen content in both years, but in 2002 KKU 72-1 was not significantly different from PI 268770 and KK 60-3. PI 152133 and KKU 1 were the poor genotypes for total fixed nitrogen content in both years and not significantly different from each other. Total nitrogen content and total fixed nitrogen content were consistent in both years. Average total fixed nitrogen content was greater in 2001 than in 2002.

Peanut genotypes in 2001 produced greater nodule dry weight and fixed more nitrogen than in 2002. Abundant soil nitrogen may have suppressed nitrogen fixation. Khan and Yoshida (1995) reported the results from pot experiment that symbiotic nitrogen fixation of peanut was not suppressed by the addition of slow released N fertilizer, even at higher doses. However, it was suppressed by high nitrogen doses as the form of urea.

Phillips *et al*. (1989) reported that leaf color score, nodule dry weight pod yield and nitrogenase activity were useful indicators for nitrogen fixing ability of peanuts. This will be the case if the control of environmental variation is successful. It seems that selection should be more effective in less fertile soils than more fertile soils, or filter cake (waste from sugar mill) should be added to reduce soil nitrogen availability in more fertile soils.

Measurement of fixed nitrogen content is the direct means for determining nitrogen fixing ability, and accomplished only in a laboratory where complicated equipment is installed. In previous study, McDonagh *et al*. (1995) found that nonnod was more suitable to be used as a reference plant for the determination of nitrogen fixation of peanut than rice. Evaluation of traits indicative of nitrogen fixation may provide an effective means under field conditions where a large number of breeding materials are evaluated if consistent parameters can be determined. Leaf color score was less variable than the other traits. Total dry weight and shoot dry weight may be useful if environmental noises are successfully controlled. Nodule dry weight was most sensitive to change in environmental conditions, possibly due to soil fertility difference and the evaluation time being too late when some of nodules were spoiled and the nodules were not completely recovered from soils. Nodule parameters may be useful in evaluation of germplasm or non-segregating breeding materials when early evaluation and destructive sampling can be carried out.

Agronomic traits

In 2001, KKU 72-1 gave the highest pod number per plant, pod weight per plant, seed number per plant, seed weight per plant and 100-seed weight, whereas KKU 1 ranked first for seed number per pod, shelling percentage and harvest index (Table 2). Nonnod did not perform well for nitrogen fixation ability and agronomic traits. In 2002, KKU 72-1 was the first rank only for 100-seed weight. In contrast, KKU 1 was the first rank for pod weight per plant, seed number per plant, seed number per pod, seed weight per pod and harvest index. Nonnod was the first rank for pod number per plant and many other traits also improved substantially compared with in 2001 except for 100-seed weight and harvest index.

It was obvious that in 2001 KKU 72-1 performed better than KKU 1 for pod number per plant, seed weight per plant and 100-seed weight because it had good nitrogen fixing ability, and thus fixed nitrogen could contribute to agronomic performance in larger extent. In 2002 KKU 1 performed better than KKU 72-1 for pod weight per plant, seed number per plant, seed number per pod and harvest index, indicating that Spanish-type cultivar (KKU 1) had better partitioning and could take more advantage of soil fertility than Virginia-type cultivar, KKU 72-1. An increase of agronomic performance of nonnod in 2002 also supported this conclusion.

Phenotypic correlation

Total nitrogen content, total fixed nitrogen content, nodule weight, shoot dry weight and leaf color score were positively correlated with each other in both years (Table 3). In 2001, nitrogen fixation parameters were positively correlated well with pod number per plant, seed number per plant, pod weight per plant, seed weight per plant and 100-seed weight, but were not correlated with seed number per pod, shelling percentage and harvest index.

In 2002, nitrogen fixation parameters were generally not correlated with agronomic traits except for 100-seed weight. However, shoot dry weight and total dry weight were positively correlated well with pod weight per plant and seed weight per plant. Pod weight per plant, seed weight per plant and 100-seed weight were strongly correlated with each other in 2001, but the correlations remained consistent in 2002 only for pod weight per plant with seed weight per plant. Correlation coefficients of 100-seed weight with pod weight per plant and seed weight per plant was

Table 2. Mean comparison of 7 peanut genotypes for agronomic traits evaluated for 2 years at Khon Kaen University's agronomy farm in 2001 and 2002.

Genotypes	Pod number per plant	Pod weight per plant (g)	Seed number per plant	Seed number per pod	Seed weight per plant (g)	Weight of 100 seed (g)	Shelling percentage (%)	Harvest index
Year 2001								
PI 268 770	5.9ab	7.43bc	8.10bc	1.35c	3.80bcd	47.57a	50.56bc	0.162d
PI 269 109	7.5ab	9.27ab	10.49abc	1.38bc	4.91abc	48.01a	52.58abc	0.184bc
PI 152 133	4.9b	4.94c	7.14c	1.46bc	2.78cd	40.57b	54.42abc	0.193b
KKU 1	8.0ab	9.85ab	13.68ab	1.70a	6.32ab	47.40a	63.28a	0.225a
KKU 72-1	9.5a	12.41a	14.73a	1.56ab	7.50a	53.03a	59.76ab	0.187bc
KK 60-3	8.0ab	9.54ab	10.95abc	1.40bc	5.38abc	48.54a	54.61abc	0.176cd
nonnod	5.7b	4.88c	8.17bc	1.44bc	2.40d	29.74c	47.28c	0.191bc
Mean	7.10	8.33	9.31	1.47	4.73	44.98	54.64	0.19
CV (%)	22.91	20.23	25.25	6.09	26.58	7.11	8.90	25.03
Year 2002								
PI 268 770	18.52c	17.74bc	27.72c	1.50cd	11.67bc	50.28bc	66.94	0.185b
PI 269 109	17.05c	19.32bc	26.60c	1.57bcd	12.75bc	54.11ab	67.70	0.192b
PI 152 133	21.75abc	11.25c	29.60c	1.37d	8.20c	34.37d	72.72	0.187b
KKU 1	24.55ab	28.97a	50.13a	2.05a	20.81a	45.37c	71.84	0.294a
KKU 72-1	19.10bc	22.24ab	32.55bc	1.71b	15.84b	60.58a	71.33	0.209b
KK 60-3	20.29bc	18.88bc	30.21c	1.50cd	13.31bc	54.65ab	70.51	0.172b
nonnod	27.45a	15.55bc	47.79ab	1.60bc	10.25c	29.60d	64.55	0.183b
Mean	15.62	19.14	34.94	1.61	13.26	46.99	69.37	0.20
CV (%)	17.99	20.64	18.17	4.85	17.71	8.17	8.48	12.18

Means in the same column followed by the same letters are not significantly different at 0.05 probability level by DMRT.

Table 3. Phenotype correlation coefficients between nitrogen fixation parameters and agronomic traits of 7 peanut genotypes (based on plot means) evaluated for 2 years at Khon Kaen University's agronomy farm in 2001 and 2002.

Parameter	Total N content	Total N fixation	Nodule weight	Shoot dry weight	Total dry weight	Leaf color score	Pod number/plant	Seed number/plant	Seed number/pod	Pod weight/plant	Seed weight/plant	Weight of 100 seed	Shelling percentage	Harvest index
Total N content		0.99**	0.59**	0.98**	0.97**	0.83**	0.50**	0.42*	-0.05	0.69**	0.61**	0.77**	0.27	-0.34
Total N fixation	1.00**		0.63**	0.97**	0.97**	0.84**	0.50**	0.42*	-0.07	0.68**	0.61**	0.77**	0.26	-0.34
Nodule weight	0.67**	0.67**		0.84**	0.59**	0.63**	0.37	0.33	0.01	0.52**	0.51**	0.72**	0.35	-0.02
Shoot dry weight	0.90**	0.90**	0.55**		0.97**	0.97**	0.57**	0.51**	0.06	0.75**	0.69**	0.81**	0.37	-0.25
Total dry weight	0.77**	0.77**	0.56**	0.55**		0.97**	0.63**	0.57**	0.08	0.81**	0.75**	0.85**	0.41*	-0.18
Leaf color score	0.78**	0.77**	0.89**	0.63**	0.58**		0.39*	0.29	-0.13	0.58**	0.54**	0.86**	0.31	-0.28
Pod number/plant	-0.44*	-0.43*	-0.51*	-0.23	0.00	-0.59**		0.96**	0.34	0.92**	0.92**	0.51**	0.65**	0.50**
Seed number/plant	-0.40*	-0.39*	-0.37	-0.16	0.18	-0.46	0.87**		0.58**	0.91**	0.94**	0.48**	0.77**	0.63**
Seed number/pod	-0.13	-0.13	0.04	-0.01	0.32	-0.02	0.14	0.60**		0.37	0.49**	0.13	0.75**	0.65**
Pod weight/plant	0.26	0.26	0.36	0.42*	0.75**	0.28	0.35	0.63**	0.70**		0.98**	0.75**	0.63**	0.37
Seed weight/plant	0.26	0.25	0.36	0.39*	0.73**	0.27	0.33	0.63**	0.74**	0.97**		0.73**	0.74**	0.46*
Weight of 100 seed	0.80**	0.81**	0.76**	0.65**	0.63**	0.82**	-0.58**	-0.39*	0.15	0.36	0.37		0.50**	0.02
Shelling percentage	0.05	0.05	0.16	-0.02	-0.06	0.13	-0.14	-0.10	0.07	-0.09	0.13	0.16		0.62**
Harvest index	-0.26	-0.25	0.19	-0.15	0.23	-0.01	0.31	0.62**	0.77**	0.73**	0.79**	0.06	0.29	

***, ** Significant at 0.05 and 0.01probability levels, respectively. ; Upper triangle are data for 2001 and lower triangle are data for 2002.**

not significant in 2002.

The high association of traits related to nitrogen fixation clearly indicated that the evaluation of all N_2-fixation parameters in order to select the superior genotypes may be not necessary. Instead, the evaluation of the traits consistent over a wide range of environments should be sufficient. In our results, leaf color score is more prospective traits followed by shoot dry weight and total dry weight. Nodule weight may not be useful if evaluation is done at harvest. Direct N_2-fixation traits such as total nitrogen and total fixed nitrogen are surely useful, but they do not interest us due to laborious laboratory work.

Arrendell *et al.* (1985) found that genotypic and phenotypic correlation of nitrogenase activity with yield were significant with phenotypic correlation coefficients ranged from 0.66 to 0.89 over sampling dates and environments. They also found that correlation between nitrogenase activity and yield were low, suggesting that nitrogenase had less effect on fruit weight than on shoot weight. Selection for families with greater N_2-fixing activity should be possible and should result in indirect selection for yield.

Environmental fluctuation affected the association of N_2-fixation parameters and agronomic traits. The high association was persistent for total dry weight and in lesser extent for shoot dry weight. The low association in 2002 indicated that excess nitrogen contributed to vegetative growth rather than agronomic performance. Screening and selection should be conducted in infertile soil. For more fertile soils, selection for total dry weight should be better than for shoot dry weight and should increase yield.

Conclusions

Virginia-type cultivar, KKU 72-1, had high nitrogen fixing ability. However, fixed nitrogen contributed to vegetative growth in more extent than to yield. Spanish-type cultivar, KKU 1, had higher assimilate partitioning and nitrogen use efficiency than KKU 72-1. These genotypes should be recombined to generate progenies for selection of superior genotypes. Leaf color score, shoot dry weight and total dry weight can be used for screening of peanut genotypes for high nitrogen fixing ability and selection under limited soil nitrogen availability should be more effective than under luxurious soil nitrogen availability.

Acknowledgements

This work was funded by the Senior Research Project of Professor Dr.Aran Patanothai under Thailand Research Fund and also supported by Peanut Improvement Project, Department of Agronomy and Plant Breeding Research Center for Sustainable Agriculture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand.

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