RESEARCH ARTICLE

**SABRAO Journal**
**of Breeding and Genetics**
**47 (4) 493-501, 2015**

# GENOTYPIC DIVERSITY OF TRAITS RELATED TO NITROGEN FIXATION IN VALENCIA PEANUT GERMPLASM

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## SUMMARY

Peanut can fix atmospheric nitrogen by symbiotic relationship with cowpea-type of rhizobium. Traits related to nitrogen fixation may be useful as select criteria for high nitrogen fixation. Thus the objective of this study was to evaluate 130 accessions of Valencia peanut for traits related to nitrogen fixation including nodule dry weight, biomass and harvest index. The new germplasm of 125 Valencia peanut accessions from New Mexico State University and International Crops Research Institute for Semi-Arid-Tropics (ICRISAT) and the 4 varieties commercially available peanut of Thailand consisting of 3 Valencia peanuts, 1 Spanish and 1 Virginia were planted in randomize complete block design (RCBD) with 4 replications during February to June 2012 and 2013. Nodule dry weight ranged from 0.16 to 0.56 g plant$^{-1}$ with mean of 0.31 g plant$^{-1}$, and biomass productions ranged from 58.38 to 97.45 g plant$^{-1}$ with mean value of 74.56 g plant$^{-1}$. Pod yields showed a wide range from 15.00 to 35.84 g plant$^{-1}$ with mean value of 24.39 g plant$^{-1}$, whereas harvest index values ranged from 0.23 to 0.45 with mean value of 0.33. Base on traits related to nitrogen fixation (nodule dry weight, biomass and harvest index), peanut accessions were separated into 4 groups.

**Key words:** Nodule dry weight, groundnut (*Arachis hypogaea* L.), biomass production

**Key findings:** Diversity of nitrogen fixation in Valencia peanut germplasm.

Manuscript received: November 8, 2014; Decision on manuscript: April 12, 2015; Manuscript accepted: May 18, 2015.


Communicating Editor: Bertrand Collard

## INTRODUCTION

Seventy eight percent of the total nitrogen pool is available as nitrogen gas in the atmosphere. However, gaseous nitrogen is not directly useful to plants and plants require sufficient mineral nitrogen for growth and development. Gaseous nitrogen can be transformed into mineral nitrogen by lighting, nitrogen fixation by free living organisms, industrial fertilizer production and many systems of symbiotic association between nitrogen fixing organisms and many plant species especially leguminous species such as beans, soybean and peanut (Giller, 2001).

Peanut (*Arachis hypogaea* L.) is traditionally grown under rainfed conditions with erratic rainfall and low soil fertility that affect to growth and peanut yield. Peanut can fix nitrogen of about 80 - 150 kg N $ha^{-1}$ (Giller *et al.*, 1987; Toomsan, 1990). Nitrogen from peanut residues can be beneficial to subsequent crops in a cropping system (McDonagh *et al.*, 1993, 1995; Toomsan *et al*., 1995). Association of rhizobium and root nodules of peanut can fix atmospheric nitrogen into nitrogen compounds that are available for peanut. However, the efficiency of nitrogen fixation in peanut depends on peanut varieties, rhizobium strains and the interaction between peanut variety and rhizobium strain (McDonagh *et al*., 1993).

Measurement of fixed nitrogen is a direct means for determining nitrogen fixing ability and accomplished only in a laboratory where complicated equipment is installed. Several traits have been identified and used as selection criteria and surrogate traits for high nitrogen fixation such as nodule dry weight, biomass production, leaf color score and nitrogenase activity. Strong and positive correlations were found between nitrogen fixation, total nitrogen and total dry matter (Pimratch *et al*., 2004).

The new peanut germplasm of Valencia type from New Mexico State University and the International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT) have not been evaluated for their nodulation efficiency and nitrogen fixation. Valencia peanut type (sub species *fastigiata*) has erect canopy with sequential branching pattern. Leaves of Valencia peanut are pale green and the leaves are larger than those of Virginia type. Valencia peanut has variations in pod size, seeds per pod and seed testa color. Valencia peanut type are early maturing, sweet taste and generally with 3 or 4 kernels per pod (Purseglove, 1977). Thus the objective of this study was to evaluate 130 accessions of Valencia peanut for traits related to nitrogen fixation including nodule dry weight, biomass and harvest index. The characterization of new germplasm sources for economically important traits is very important for breeding and effective utilization of the germplasm.

## MATERIALS AND METHODS

### Crop management and experimental design

The experiment was conducted at the Field Crop Research Station of Khon Kaen University, Khon Kaen, Thailand (lat 16º, 28’ N, long 102º 48’ E, 200 m above mean sea level). One hundred and thirty peanut accessions consisting of 125 accessions of Valencia peanut from New Mexico State University and the International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT), 3 peanut varieties (KS1, KS2 and KK4), one Spanish peanut type (KKU40) and one Virginia peanut type (KKU 60) commercially available in Thailand were used in this study (Table 1). The experiment was laid out in a randomized complete block design with 4 replications during February to June 2012 and 2013. Plot size was 2 x 5 $m^2$ and the spacing was 50 cm between rows and 20 cm between plants within rows.

Seeds were treated with captan (3a,4,7,7a-tetrahydro-2-[(trichloromethyl) thio]-1H-isoindole-1,3 (2H)-dione) at the rate of 5 g $kg^{-1}$ seeds before planting to control fungal diseases. Seeds were planted 3-4 seed $hill^{-1}$ and pre-emergence weeds were controlled by alachlor (2-cholro-2’,6’-diethyl-*N*-(methoxymethyl) acetanilide 48%, w/v, emulsifiable concentrate) at the rate of 3 L $ha^{-1}$ at planting after application of water. *Bradyrhizobium* inoculation (mixture of strains THA 201 and THA 205; Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkok, Thailand) was accomplished by applying a water-diluted commercial peat-based inoculum of *Bradyrhizobium* on the rows of peanut at 2 day after planting. At 10-15 DAP, peanut seedlings were thinned to obtain 2 plants per hill and weeds were controlled by hand weeding. Chemical fertilizer $N:P_2O_5:K_2O$ was applied the rate of 0, 56.25, 37.5 kg $ha^{-1}$, respectively. Gypsum ($CaSO_4$) at the rate of 312 kg $ha^{-1}$ was applied at 40-45 DAP after weeding control. Carbofuran (2,3-dihydro-2,2-dimethylbenzo-furan-7-ylmethylcarbamate 3% granular) was used at pod setting stage to protect the crop from the subterranean ants (*Dorylus orientalis*).

**Table 1.** Valencia peanut accessions and seed source.

| Entry No. | Accession | Source | Entry No. | Accession | Source | Entry No. | Accession | Source |
|---|---|---|---|---|---|---|---|---|
| 1 | PI468225 | New Mexico | 45 | PI493325 | New Mexico | 89 | Valencia - C | New Mexico |
| 2 | PI475913 | New Mexico | 46 | PI493339 | New Mexico | 90 | M C Ran | New Mexico |
| 3 | PI475921 | New Mexico | 47 | PI493340 | New Mexico | 91 | ICG 115 | India |
| 4 | PI475925 | New Mexico | 48 | PI493344 | New Mexico | 92 | ICG 297 | Mauritius |
| 5 | PI476074 | New Mexico | 49 | PI493360 | New Mexico | 93 | ICG 332 | Brazil |
| 6 | PI476078 | New Mexico | 50 | PI493373 | New Mexico | 94 | ICG 397 | USA |
| 7 | PI476079 | New Mexico | 51 | PI493382 | New Mexico | 95 | ICG 1142 | Benin |
| 8 | PI476089 | New Mexico | 52 | PI493405 | New Mexico | 96 | ICG 1274 | Indonesia |
| 9 | PI493381 | New Mexico | 53 | PI493415 | New Mexico | 97 | ICG 1399 | Malawi |
| 10 | PI493521 | New Mexico | 54 | PI493442 | New Mexico | 98 | ICG 2738 | India |
| 11 | PI493536 | New Mexico | 55 | PI493446 | New Mexico | 99 | ICG 3673 | Korea |
| 12 | PI493562 | New Mexico | 56 | PI493451 | New Mexico | 100 | ICG 3681 | USA |
| 13 | PI497447 | New Mexico | 57 | PI493458 | New Mexico | 101 | ICG 4670 | Sudan |
| 14 | PI497459 | New Mexico | 58 | PI493461 | New Mexico | 102 | ICG 5221 | Argentina |
| 15 | PI501293 | New Mexico | 59 | PI493470 | New Mexico | 103 | ICG 5475 | Kenya |
| 16 | PI501985 | New Mexico | 60 | PI493484 | New Mexico | 104 | ICG 5609 | Sri Lanka |
| 17 | PI536300 | New Mexico | 61 | PI493501 | New Mexico | 105 | ICG 6022 | Sudan |
| 18 | PI536307 | New Mexico | 62 | PI493523 | New Mexico | 106 | ICG 6201 | Cuba |
| 19 | PI599612 | New Mexico | 63 | PI493565 | New Mexico | 107 | ICG 6646 | Unknown |
| 20 | PI602494 | New Mexico | 64 | PI493566 | New Mexico | 108 | ICG 6888 | Brazil |
| 21 | PI259580 | New Mexico | 65 | PI493584 | New Mexico | 109 | ICG 7181 | India |
| 22 | PI259601 | New Mexico | 66 | PI493612 | New Mexico | 110 | ICG 8106 | Peru |
| 23 | PI306361 | New Mexico | 67 | PI493624 | New Mexico | 111 | ICG 8517 | Bolivia |
| 24 | PI314980 | New Mexico | 68 | PI493629 | New Mexico | 112 | ICG 9315 | USA |
| 25 | PI315612 | New Mexico | 69 | PI493630 | New Mexico | 113 | ICG 10092 | Zimbabwe |
| 26 | PI338337 | New Mexico | 70 | PI493660 | New Mexico | 114 | ICG 10474 | Cuba |
| 27 | PI365564 | New Mexico | 71 | PI493666 | New Mexico | 115 | ICG 10554 | Argentina |
| 28 | PI390432 | New Mexico | 72 | PI493688 | New Mexico | 116 | ICG 10566 | Congo |
| 29 | PI406718 | New Mexico | 73 | PI493810 | New Mexico | 117 | ICG 10890 | Peru |
| 30 | PI407451 | New Mexico | 74 | PI493816 | New Mexico | 118 | ICG 111444 | Argentina |
| 31 | PI429427 | New Mexico | 75 | PI493865 | New Mexico | 119 | ICG 13856 | Uganda |
| 32 | PI429430 | New Mexico | 76 | PI494019 | New Mexico | 120 | ICG 13858 | Uganda |
| 33 | PI493507 | New Mexico | 77 | PI497642 | New Mexico | 121 | ICG 14106 | Zaire |
| 34 | PI493514 | New Mexico | 78 | DC 2120 (S3873) | New Mexico | 122 | ICG 14127 | Zaire |
| 35 | PI493518 | New Mexico | 79 | DC 2440 (S3897) | New Mexico | 123 | ICG 14710 | Cameroon |
| 36 | PI502023 | New Mexico | 80 | S-3653 | New Mexico | 124 | ICG 15042 | Unknown |
| 37 | PI508278 | New Mexico | 81 | S-3881 | New Mexico | 125 | ICG 15309 | Brazil |
| 38 | PI536121 | New Mexico | 82 | New BG | New Mexico | 126 | KS 1 | Thailand |
| 39 | Grif13802 | New Mexico | 83 | 23322 | New Mexico | 127 | KS 2 | Thailand |
| 40 | PI501269 | New Mexico | 84 | S-3840 | New Mexico | 128 | KK4 | Thailand |
| 41 | PI576604 | New Mexico | 85 | Kremena | New Mexico | 129 | KKU 60 | Thailand |
| 42 | Breeding line | New Mexico | 86 | NM 052565 | New Mexico | 130 | KKU 40 | Thailand |
| 43 | PI409037 | New Mexico | 87 | Rossita | New Mexico | | | |
| 44 | PI468208 | New Mexico | 88 | Valencia - A | New Mexico | | | |

Pests and diseases were controlled twice a month by applying carbosulfan [2-3-dihydro-2,2-dimethylbenzofuran-7-yl (dibutylaminothio) methylcar-bamate 20% w/v, water soluble concentrate] at the rate of 2.5 L $ha^{-1}$, methomyl [*S*-methyl-*N*-((methylcarbamoyl)oxy) thioaceti-midate 40% soluble powder] at the rate of 1.0 kg/ha and carboxin [5,6-dihydro-2-methyl-1,4-oxathine-3-carboxanilide 75% wettable powder] at the rate of 1.68 kg $ha^{-1}$. Sprinkler irrigation system was installed to supply water to the peanut plants from planting to harvest.

## Data collection

### *Soil and weather parameters*

Weather data were obtained from nearby meteorological station, Khon Kaen University, Khon Kaen, Thailand for both years.

The soil samples at the depth 0-30 cm were analyzed to determine the physical and chemical properties (Table 2).

*Traits measurement*

At the final harvest, 5 plants in each plot were randomly selected. Nodules were removed from the roots and oven dried at 80 ºC for 48 h or until the weight was constant and dry weight was measured. Shoot fresh weight was determined in the field. The shoot sample of 1 kg fresh weight was oven-dried at 80 ºC for 48 h or until the weight was constant and dry weight was measured. The pods form harvest area (4.8 $m^2$) in each plot were removed from the plants and air-dried to obtain approximately 8% moisture content, and pod dry weight was determined. Biomass production was calculated based on shoot dry weight and pods dry weight (without roots). Harvest index was computed as the ratio of total pod weight to total biomass at the final harvest.

*Statistical analysis and cluster analyses*

Analysis of variance was performed for all characters in each year, error variances were tested for homogeneity, and the data of 2 years with variance homogeneity were combined. The analyses of variance were done using MSTAT-C package (Bricker, 1989).

A data matrix of the 130 accessions was constructed using means of nodule dry weight, biomass and HI. The cluster analysis based on Ward's method and Squared Euclidian distance was performed and the dendrogram was constructed. All calculations were performed in SAS 6.12 (SAS, 2001).

## RESULTS

### Meteorological conditions and soil properties

*Weather conditions*

The experiment was conducted under field conditions for 2 years in dry seasons 2012 and 2013. The average air temperatures were 22.4 to 34.7 ºC in 2012 and 23.5 to 35.5 ºC in 2013 (Figure 1). There was rainfall in both years (Figure 1a, 1b). Rainfall in the dry season 2012 was higher than in 2013 especially during late growing season (75-105 DAP). Patterns of weather conditions were similar for 2 years.

*Soil properties*

The soil is Yasothorn series with sand soil texture in both years, and % sand, % silt and % clay in 2012 and 2013 were 90.23, 7.79 and 1.96, and 92.58, 6.00 and 1.42, respectively (Table 2). pH values were 6.39 in 2012 and 6.63 in 2013, and electrical conductivity (EC) value was 0.04 dS $m^{1}$ in both years. Cation exchange capacity (CEC) values were 3.43 c mol/kg in 2012 and 1.88 c mol $kg^{-1}$ in 2013. Organic matter values and total nitrogen values were low in both years, showing nitrogen deficiency in the soil. Available P and exchangeable K were also deficient in both years, whereas exchangeable Ca values were rather high in both years (409 mg $kg^{-1}$ in 2012 and 391 mg $kg^{-1}$ in 2013), indicating that calcium was sufficient.

**Table 2.** Chemical and physical properties of the soil in the experimental fields of Khon Kaen University at the depth 0-30 cm in 2 years.

| Soil proper-ties | pH (1:1 $H_20$) | EC (1:5 H20) (dS/m ) | CEC (c mol/ kg) | OM (%) | Total N (%) | Avai lable P (mg/ kg) | Exchangeable | | Particle size, mum (USDA system) | | | Soil tex-ture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | K (mg/ kg) | Ca (mg/k g) | Sand: 2.0-0.05 (%) | Silt: 0.05-0.002 (%) | Clay: <0.002 (%) | |
| 2012 | 6.39 | 0.04 | 3.43 | 0.51 | 0.02 | 30.8 | 39.9 | 409 | 90.23 | 7.79 | 1.96 | Sand |
| 2013 | 6.63 | 0.04 | 1.88 | 0.49 | 0.01 | 35.6 | 42.5 | 391 | 92.58 | 6.00 | 1.42 | Sand |

EC = Electrical conductivity, CEC= Cation exchange capacity and OM = Organic matter

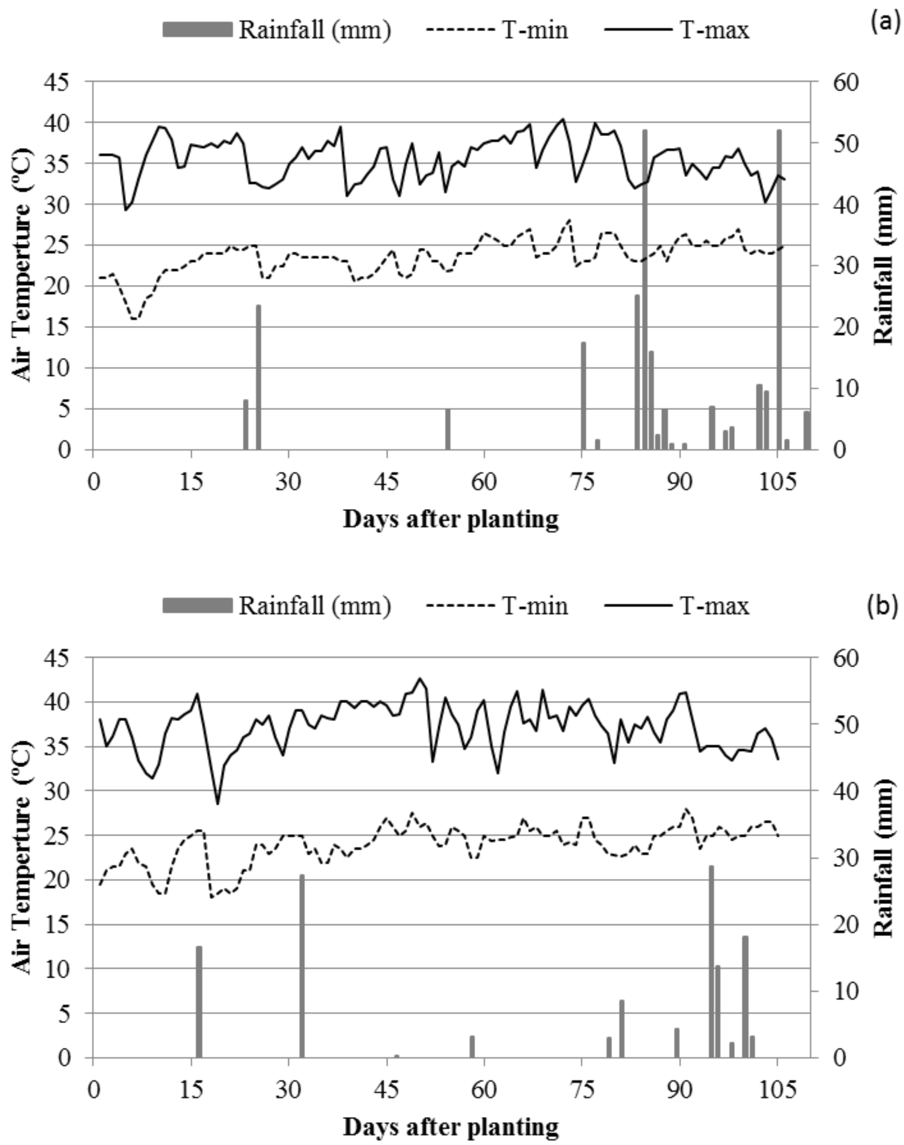


**Figure 1** Maximum air temperatures (T-max), minimum air temperatures (T-min) ($^{O}C$), rainfall (mm), during the crop growth period of Valencia Peanut in the dry season 2012 (a) and 2013 (b)

*Nodule dry weight (NDW), pod yield, biomass and harvest index*

Years were significantly different for pod yield ($P \leq 0.01$) and nodule dry weight ($P \leq 0.05$), but they were not statistically different for biomass and harvest index (Table 3). Significant differences ($P \leq 0.01$) among peanut genotypes were observed for nodule dry weight, pod yield, biomass and harvest index. However, genotype × year interactions were also significant ($P \leq 0.01$) for all characters and also contributed to lower portions than did genotype.

Peanut genotypes were also different for nodule dry weights, ranging from 0.16 to 0.56 g plant$^{-1}$ with mean of 0.31 g plant$^{-1}$ and biomass production ranging from 58.38 to 97.45 g plant$^{-1}$ with mean value of 74.56 g plant$^{-1}$ (Table 4). Peanut genotypes had a rather wide range for pod yield from 15.00 to 35.84 g plant$^{-1}$ with mean value of 24.39 g plant$^{-1}$, whereas they had rather narrow range for harvest index from 0.23 to 0.45 with mean value of 0.33.

**Table 3.** Mean squares for nodule dry weight, biomass, pod yield and harvest index (HI) of 130 peanut accession across 2 years.

| Source | DF | Nodule dry weight | Biomass | Pod yield | HI |
|---|---|---|---|---|---|
| Years | 1 | 0.72* | 20585.7$^{ns}$ | 3784.8** | 0.014$^{ns}$ |
| Reps. Within Years | 6 | 0.08 | 4046.7 | 59.2 | 0.060 |
| Accessions | 129 | 0.03** | 391.2** | 91.2** | 0.011** |
| Accessions x Years | 129 | 0.02** | 320** | 57.2** | 0.005** |
| Pool error | 774 | 0.01 | 164.3 | 9.8 | 0.003 |
| CV (%) | | 30.8 | 17.18 | 12.76 | 15.47 |

$^{ns}$, *, ** = non-significant and significant at $P \leq 0.05$ and $P \leq 0.01$ probability levels, respectively.

**Table 4.** Mean, minimum (min), maximum (max) of nodule dry weight (NDW; g plant$^{-1}$), biomass (g plant$^{-1}$), pod yield (g plant$^{-1}$) and harvest index (HI) of 130 peanut accession across 2 years were grouped into 4 clusters.

| Cluster | No. accession | | NDW | Biomass | PY | HI |
|---|---|---|---|---|---|---|
| 1 | 63 | Min | 0.19 | 71.62 | 17.82 | 0.24 |
| | | Max | 0.43 | 79.77 | 32.44 | 0.42 |
| | | Average | 0.31 | 75.66 | 24.79 | 0.33 |
| 2 | 25 | Min | 0.22 | 80.69 | 20.48 | 0.23 |
| | | Max | 0.56 | 97.45 | 35.84 | 0.43 |
| | | Average | 0.32 | 84.64 | 25.46 | 0.31 |
| 3 | 33 | Min | 0.18 | 64.06 | 19.05 | 0.27 |
| | | Max | 0.40 | 71.21 | 33.68 | 0.45 |
| | | Average | 0.30 | 68.46 | 23.68 | 0.35 |
| 4 | 9 | Min | 0.16 | 58.38 | 15.00 | 0.26 |
| | | Max | 0.38 | 62.83 | 24.86 | 0.40 |
| | | Average | 0.30 | 61.19 | 21.20 | 0.35 |
| Total | 130 | Min | 0.16 | 58.38 | 15.00 | 0.23 |
| | | Max | 0.56 | 97.45 | 35.84 | 0.45 |
| | | Average | 0.31 | 74.56 | 24.39 | 0.33 |
| | | S.E | 0.005 | 0.30 | 23.56 | 0.001 |

*Cluster analysis*

Base on traits related to nitrogen fixation including nodule dry weight, biomass and HI, Valencia peanut accessions could be classified into 4 groups ($R^2$ = 0.85) (Figure 2). Sixty three peanut accessions (PI468225, PI476078, PI476079, PI493381, PI493521, PI493536, PI497447, PI501985, PI536300, PI536307, PI599612, PI602494, PI315612, PI406718, PI429427, PI429430, PI493507, PI493514, PI493518, PI502023, PI508278, Grif13802, PI501269, PI576604, Breeding-line, PI409037, PI493339, PI493340, PI493344, PI493405, PI493442, PI493446, PI493484, PI493523, PI493612, PI493624, PI493629, PI493660, PI493666, PI493810, PI493816, PI493865, PI497642, DC 2440 (S3897), M C Ran, ICG 332, ICG 1142, ICG 1399, ICG 2738, ICG 3673, ICG 4670, ICG 5475, ICG 5609, ICG 6201, ICG 6646, ICG 9315 ICG 10890, ICG 13856, ICG 15309, KS 1, K4, KKU 60 and KKU 40) formed group 1, which was the largest group. This group had nodule dry weight ranging from 0.19 to 0.43 g plant$^{-1}$ with mean of 0.31 g plant$^{-1}$, biomass ranging from 71.62 to 79.77 g plant$^{-1}$ with mean of 75.66 g plant$^{-1}$, harvest index ranging from 0.24 to 0.42 with mean of 0.33 and pod yield ranging from 17.82 to 32.44 g plant$^{-1}$ with mean of 24.79 g plant$^{-1}$ (Table 4).

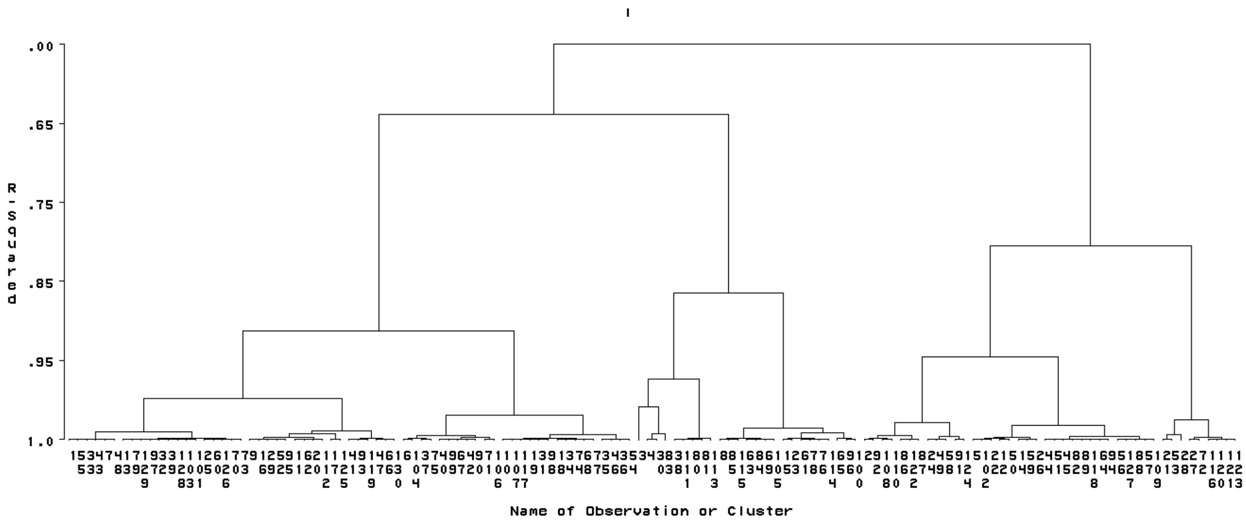


**Figure 2.** Dendrogram produced by Ward's minimum variance cluster analysis base on mean traits related to nitrogen fixation of 130 Valencia peanut accessions across 2 years.

Group 2 consisted of 25 peanut accessions (PI475921, PI475925, PI476089, PI501293, PI306361, PI407451, PI536121, PI493501, PI493565, PI493584, PI493630, PI494019, DC 2120 (S3873), S-3653, S-3881, 23322, S 3840 Kremena, ICG 1274, ICG 3681, ICG 6022, ICG 8517, ICG 10092, ICG 10474 and ICG 10554). This group had nodule dry weight ranging from 0.22 to 0.56 g plant$^{-1}$ with mean of 0.32 g plant$^{-1}$, biomass ranging from 80.69 to 97.45 g plant$^{-1}$ with mean of 84.64 g plant$^{-1}$, HI ranging from 0.23 to 0.43 with mean of 0.31 and pod yield ranging from 20.48 to 35.84 g plant$^{-1}$ with mean of 25.46 g plant$^{-1}$

Group 3 consisted of 33 accessions (PI475913, PI476074, PI493562, PI497459, PI259601, PI314980, PI338337, PI468208, PI493325, PI493360, PI493373, PI493382, PI493451, PI493458, PI493461, PI493470, PI493566, New BG, NM 052565, Rossita, Valencia – A, Valencia – C, ICG 115, ICG 297, ICG 397, ICG 5221, ICG 6888, ICG 7181, ICG 8106, ICG 111444, ICG 14127, ICG 15042 and KS 2). This group had nodule dry weight ranging from 0.18 to 0.40 g plant$^{-1}$and mean of 0.30 g plant$^{-1}$, biomass production ranging from 64.06 to 71.21 g plant$^{-1}$ and mean of 68.46 g plant$^{-1}$, HI ranging from 0.27 to 0.45 and mean of 0.35 and pod yield ranging from 19.05 to 33.68 g plant$^{-1}$ and mean of 23.68 g plant$^{-1}$.

Group 4 consisted of 9 accessions (PI259580, PI365564, PI390432, PI493415, PI493688, ICG 10566, ICG 13858, ICG 14106 and ICG 14710). This group had nodule dry weight ranging from 0.16 to 0.38 g plant$^{-1}$ with mean of 0.30 g plant$^{-1}$, biomass ranging from 58.38 to 62.83 with mean of 61.19 g plant$^{-1}$, HI ranging from 0.26 to 0.40 with mean of 0.35 and pod yield ranging from 15.00 to 24.86 g plant$^{-1}$ with mean of 21.20 g plant$^{-1}$

Group 2 consisting of 25 accessions (such as ICG 3681, ICG 6022, ICG 10554, PI493630 and PI407451 etc.) had the highest nodule dry weight, biomass, pod yield and HI, whereas groups 4 consisting of 9 accessions (such as PI390432, PI259580, PI365564, PI493415 and ICG 10566 etc.) had the lowest nodule dry weight, biomass, harvest index and pod yield.

## DISCUSSION

The traits related to nitrogen fixation consisting of nodule number, nodule dry weight, leaf color score, biomass production, shoot dry weight harvest index and nitrogenase activity had strong and positive correlations with nitrogen fixation (Philips *et al*., 1989; Pimratch *et al*., 2004, 2008). As most peanut growing soils are not fertile and peanut being a legume is dependent on atmospheric nitrogen for fixation nitrogen fixation traits are, therefore, closely related to growth parameters and pod yield. Harvest index is correlated with nitrogen fixation, if fixed nitrogen gives more contribution to pod yield than vegetative growth, and nitrogenase activity is related to nitrogen fixation as this parameter is an indirect assessment for nitrogen fixation. Most of the peanut growers are from Semi-Arid Tropics and cannot afford to apply synthetic fertilizers. Selection of varieties with high nodules number and high yield helps growers to reduce the input cost on commercial fertilizers. Selection for surrogate traits as an indirect method for nitrogen fixation is much easier than direct selection for nitrogen fixation which is difficult and can be performed in laboratory.

Genotypic diversity is important source of germplasm for breeding program. Breeders can select peanut accessions for improving the characters. Peanut Genotypes with high nitrogen fixation and high yield should be used as parents in peanut breeding programs for high nitrogen fixation (Pimratch *et al*., 2008). Krishna *et al*. (2004) identified 48 Valencia peanut from 20 different country by using microsatellite makers.

Genotype variations were observed for all characters under study. The Valencia peanut germplasm had high variations in nodule dry weight, biomass production, pod yield and harvest index. The range of variation for nodule dry weight in this study was from 0.16 to 0.56 g $plant^{-1}$. In previous study using other germplasm under well-irrigated condition, the range of nodule dry weight was from 0.38 to 0.57 g $plant^{-1}$ (Dinh *et al*., 2013). The results in this study were similar to those in previous study.

The peanut accessions were classified into 4 groups based on Squared Euclidian distance matrix which indicated degree of similarity. High values showed high similarity and vice versa. Group 2 consisting of 25 accessions had the highest biomass and pod yield. The accessions in this group should be selected as parents in breeding programs. Group 4 consisting of 9 accessions had low biomass, pod yield and nodule dry weight. In previous investigation, the variation in biomass production ranged from 6,766 -8,875 kg $ha^{-1}$ (Pimratch *et al*., 2008). In this study, the variation in biomass productions ranged from 5,838 to 9,845 kg $ha^{-1}$ was observed.

The peanut genotypes with high nodule dry weight can be used as parents by peanut breeders to incorporate high nitrogen fixation traits into cultivated varieties with high yield and good agronomic traits. The variations in traits related to nitrogen fixation are also important for prediction of the possible success in breeding programs for improving nitrogen fixation in Valencia peanut.

## CONCLUSION

This study investigated the variation in nodule dry weight, biomass, pod yield and harvest index in 130 accessions of Valencia peanut germplasm. The results indicated that high variation was observed for all characters under study. The accessions with high biomass production, pod yield and nodule dry weight are promising for use as parents in breeding programs.

## ACKNOWLEDGEMENTS

This work was supported by the Higher Education Research Promotion and National Research University Project of Thailand, Office of the Higher Education Commission, through the Food and Functional Food Research Cluster of Khon Kaen University (KKU), Thailand. This work were also partially supported by Peanut CRSP NMS 72 project by USAID through University of Georgia ECG-A-00-0700001-00 and peanut genotypes for this study were kindly provided by ICRISAT, New Mexico State University, USA. Grateful acknowledgement is made to the Thailand Research Fund, for providing financial supports to this research through the Senior Research Scholar Project of Professor Dr. Sanun Jogloy (Project No RTA 5880003). Acknowledgment is extended to the Thailand research fund (IRG5780003), KKU and faculty of agriculture, KKU for providing financial supported for manuscript preparation activities.

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