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GROWTH, YIELD, AND SEED QUALITY OF PEANUT GENOTYPES UNDER DROUGHT AND POOR NITROGEN CONDITIONS

Nguyen Thi Thanh Hai, Dinh Thai Hoang, Vu Dinh Chinh, Nguyen Viet Long*

Faculty of Agronomy, Vietnam National University of Agriculture

Email: nvlong@vnua.edu.vn*

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ABSTRACT

This experiment was conducted in the spring cropping season of 2015 to evaluate growth, yield, and seed quality of peanut genotypes under drought and poor nitrogen field conditions at the Faculty of Agronomy, Vietnam National University of Agriculture. Seven high yielding peanut lines/cultivars and the Dau Giay cultivar (control) were laid out in a randomize complete block design with three replications. Irrigation was stopped for 45 days during the period from 30 to 75 days after sowing, then re-watered until harvest. Fertilizer (without nitrogen) was applied following the normal procedure. The results showed that under drought and poor nitrogen conditions, peanut genotypes performed well with a high tolerance to major diseases and insects, and had higher yields than the control (except for KKU60). D18 and Tainan9 showed the highest yields and the best grain quality under drought and poor nutrient conditions. These two genotypes have the potential for development in drought and poor soil conditions in Vietnam.

Keywords: Drought, nitrogen shortage, peanut, Vietnam.

Nghiên cứu khả năng sinh trưởng, năng suất và chất lượng của một số dòng, giống lạc trong điều kiện hạn và thiếu đạm

TÓM TẮT

Nghiên cứu được tiến hành trong vụ Xuân 2015 nhằm đánh giá khả năng sinh trưởng, năng suất và chất lượng của một số dòng, giống lạc trong điều kiện hạn nhân tạo trên đất nghèo hữu cơ và đạm, Khoa Nông học, Học viện Nông nghiệp Việt Nam. Bảy giống lạc năng suất cao được phát triển từ tập đoàn giống nhập nội năm 2011 và giống đối chứng Đậu Giấy (giống địa phương thích ứng với đất nghèo dinh dưỡng) được bố trí theo kiểu khối ngẫu nhiên hoàn chỉnh (RCBD), với ba lần nhắc lại. Gây hạn bằng cách ngừng tưới trong 45 ngày từ 30 đến 75 ngày sau gieo, sau đó tưới trở lại đến khi thu hoạch. Phân bón (trừ đạm) được bón như quy trình thông thường. Kết quả cho thấy trong điều kiện hạn và nghèo dinh dưỡng đạm, các dòng, giống lạc sinh trưởng tốt và chống chịu tốt với một số loài sâu, bệnh chính, có năng suất cao hơn giống đối chứng. Nghiên cứu này đã xác định được dòng D18 và giống Tainan 9 là những dòng giống tốt nhất có năng suất hạt và hàm lượng dinh dưỡng cao. Đây sẽ là những giống lạc tiềm năng phục vụ phát triển sản xuất tại các vùng đất khó khăn tại Việt Nam.

Từ khóa: Hạn, lạc, thiếu đạm, Việt Nam.

1. INTRODUCTION

Vietnam, a center of climate change, has been facing the risks and challenges caused by drought, one of the phenomenons associated with global warming most severely affecting agricultural production. Because of erratic rainfall and a downward annual rainfall trend, drought occurs more frequently and prolongedly. In 2013, the precipitation reduced on average 10-30% but some areas saw reductions up to 30-70% (in provinces from Ha Tinh to Binh Thuan) in comparison with previous years. Drought affected about 60,000 ha of the cultivated land in central Vietnam and caused serious damage to crop yields (www.sonongnghiep.daklak.gov.vn). In Tay Nguyen, yields of coffee normally over 27,500 ha were reduced 30-40% with economic damages estimated around 500 billion VND due to drought (www.cand.com.vn). Exploiting crops that are able to adapt to drought conditions is an important and economical strategy.

Peanut is an important industrial and food crop in Vietnam. It is considered to be a drought tolerant crop as well as a soil renovation and enrichment crop because of its nitrogen fixing ability. Due to the self-sourcing nitrogen ability, peanut does not depend on the application of inorganic nitrogen which is considered to be the agent causing soil degeneration, especially under drought conditions. Using peanut in a rotational system will contribute effectively to sustaining agricultural production. However, drought tolerance of peanut is a complex trait and varies at different crop growth stages. There have been a number of studies characterizing drought tolerance in peanuts. Nageswara Rao *et al.* (1985) found that water stress during the vegetative stage did not have a detrimental effect on peanut yield. Interestingly, drought stress induced early or at pre-flowering followed by re-watering has been shown to increase pod yield (Puangbut *et al.*, 2009). Nevertheless, peanut was the most susceptible to drought from flowering to the pod filling stage (Patil and Gangavane, 1990). Previous studies demonstrated that having a high nitrogen fixing ability could be a mechanism to help peanut tolerate drought and to increase yield and quality (Pimratch *et al.*, 2008; Htoon *et al.*, 2013; Dinh Thai Hoang *et al.*, 2013; Dinh Thai Hoang *et al.*, 2014). Unfortunately, most of the peanut production areas in Vietnam grow the crop under semi-arid conditions where drought is one of the most common climate factors, leading to restrictions in production. Drought not only reduces growth and yield, but also is a main reason for the reduction in seed nutritional quality. Moreover, because of nitrogen fixation, peanut is often used as a soil renovation plant for poor nutrient areas. A lack of nutrients in these areas has been a limiting factor which constrains peanut production.

Breeding high yielding peanut cultivars able to adapt to drought and poor nutrient conditions, therefore, is an important strategy. In Vietnam, although many drought tolerant varieties with high yield have been released for production (Ministry of Agriculture and Rural Development, 2010), information about growth, yield, and nutrient accumulation of each genotype, especially under drought and poor nutrient conditions, has not been adequately studied. Our study aims to screen high yielding and high seed quality peanut cultivars under drought and poor nitrogen conditions to support production in regions where cultivation meets difficulties in irrigation and nutrient management.

2. MATERIALS AND METHODS

This experiment was conducted during the spring cropping season in 2015 at the Department of Industrial and Medicinal Plants Sciences (IMP), Faculty of Agronomy, Vietnam National University of Agriculture (VNUA). Experimental land was an alluvial soil with pH = 6.97, rich exchangeable P_2O_5 (36.88 mg/100g) and medium exchangeable K_2O (12.24 mg/100g) but poor organic matter (0.66%) and nitrogen (0.075%). Chemical fertilizer without nitrogen (muriate of potash and trip superphosphate only) was applied following the recommendations of the Ministry of Agriculture and Rural Development (2011). The experiment was planted in a randomize complete block design with three replications. Local variety Dau Giay (control) and 7 high yielding peanut genotypes with different origins were used (Table 1). Water was applied normally until the 4-5 leaf stage (30 days after sowing) and then no water was applied for 45 days to subject the plants to drought-like conditions during flowering and pod forming stages. After that, water was applied as normal until harvest. A rainout shelter was used to protect the soil from rainfall during the drought stages.

Table 1. List of peanut line/cultivars

Penut genotypes	Origin, characteristics
Dau Giay (control)	Local variety, adapted to drought and poor nutrient conditions
KS2	High yield, introduced variety from Thailand in 2011
Tainan9	High yield, introduced variety from Thailand in 2011
KKU60	High yield, introduced variety from Thailand in 2011
D18	High yield, potential line from IMP, VNUA
Tifton8	High yield, introduced variety from United State in 2011
L12	High yield, breeding by Legume Research and Development Center (LRDC), Vietnam
L08	High yield, introduced variety from China, developed by LRDC, Vietnam

Data collections:

Growth duration, germination rate, and infection rate of major diseases and insects were monitored according to the QCVN 2011:01:57 (Ministry of Agriculture and Rural Development, 2011). Several growth and physiological traits were determined at flowering and pod filling stages, including SPAD readings, leaf area index, nodule number, and dry matter accumulation in shoots and nodules. SPAD index values were taken using a SPAD 502 Meter (Japan) on leaflets of the second fully expanded leaf from the top of the main stem of sample plants. Leaf area index (LAI) was equal to the plant density divided by the leaf area (m^2/m^2) (using gravimetric method). Shoots (stem and leaves) were dried at 80°C for 48 hours to determine dry matter accumulation. Roots were collected to count the number of nodules and then dried in an oven at 80°C for 48 hours to determine nodule dry weight (Dinh Thai Hoang and Vu Dinh Chinh, 2011; Dinh Thai Hoang *et al.*, 2013).

At harvest time, 10 sample plants in each pot were collected to determine a range of morphological and yield traits (QCVN 2011:01:57 - Ministry of Agriculture and Rural Development, 2011). Morphological traits collected included plant height (cm) measured from the cotyledon axil to the top of the main stem and average branch length (cm) measured from the cotyledon axil to the top of each of the cotyledonary lateral branches. Yield traits collected included total pod and mature pod number, 100 dry pod weight (g) and 100 dry seed weight (g) (both at seed and pod moisture around 12%), seed rate (%) equal to the percentage of dry seed weight of 100 dry pods per 100 pod dry weight, individual yield (g/plant), and total pod yield (quintal/ha). Sample seeds of each genotype were also collected to be analyzed for nutritional quality by measuring the lipid content via the Soxhlet method (1879) and the protein content via the Kjeldahl method (1833).

The data were subjected to analysis of variance according to a randomize complete block design using the IRRISTAT 5.0 program. Least significant difference (LSD) was used to compare means.

3. RESULTS AND DISCUSSION

3.1. Time duration, germination rate, plant height, and branch length of peanut genotypes under drought and poor nitrogen conditions

There were no clear differences in germination rate (90.7-94.1%), germination time (3-5 DAS), and flowering time (40-42 DAS) among peanut genotypes (Table 2). This was advantagous to evaluate growth, yield, and seed quality of genotypes objectively under drought conditions. Total growth duration of peanut genotypes ranged from 116-123 days. Among them, Tifton8 was the latest maturing genotype, whereas KS2 and L12 were the earliest maturing genotypes.

Table 2. Growth duration, plant height and branch length of peanut genotypes

Genotypes	Germination rate (%)	Germination duration (DAS)	Flowering time (DAS)	Total growth duration (days)	Plant height (cm)	Branch length (cm)
Dau Giay	92.9	4	40	122	41.6	30.5
KS2	94.1	3	40	116	48.5	40.5
Tainan9	93.0	4	41	117	36.4	33.3
KKU60	91.8	3	42	120	39.7	34.7
D18	91.0	4	40	121	39.4	37.8
Tifton8	91.7	3	41	123	43.5	36.1
L12	91.3	5	41	116	35.7	32.6
L08	90.7	5	42	118	38.5	33.7
$LSD_{0.05}$	-	-	-	-	1.39	0.64
CV%	-	-	-	-	2.00	1.70

Plant height of peanut genotypes ranged from 35.7 to 48.5 cm. KS2 had the highest plant height, whereas L12 had the shortest. KS2 also had the longest branch length (40.5 cm), whereas Dau Giay had the shortest branch length (30.5 cm) (Table 2).

3.2. Physiological characteristics of peanut genotypes under drought and poor nitrogen conditions

Leaf area index (LAI) and SPAD readings of studied peanut genotypes increased from flowering to pod filling stage. After flowering, upper parts (stem and leaves) developed faster to synthesize organic matter to create fruits. At pod filling stage, growth of the upper plant portions reached the highest rate. At this time, the leaves had their maximum chlorophyll content leading to the greatest photosynthetic rates. After that, organic matter began accumulating in the pods, and leaves changed color from green to yellow because of decreasing chlorophyll content (Doan Thi Thanh Nhan *et al.*, 1996). Therefore, leaf area and SPAD (chlorophyll index) initially had upward trends until they peaked at the pod filling stage. Our results are similar with those of Nguyen Thi Thanh Hai *et al.* (2010, 2015) and agreed with the study of Dinh Thai Hoang and Vu Dinh Chinh (2011) under non-drought stress conditions. At the pod filling stage, LAI and SPAD values of peanut genotypes ranged from 3.54 to 4.81 m^2/m^2 and from 32.01 to 36.08, respectively. Among genotypes, KS2 and Tifton8 had the

Table 3. Leaf area index and SPAD index of peanut genotypes

Genotypes	Flowering stage		Pod filling stage	
	LAI (m^2/m^2)	SPAD	LAI (m^2/m^2)	SPAD
Dau Giay	0.72	29.30	4.81	32.06
KS2	0.82	28.97	4.81	33.32
Tainan9	0.63	31.39	4.06	33.80
KKU60	0.78	29.08	3.79	32.01
D18	0.73	28.95	4.25	35.99
Tifton8	0.68	33.46	4.25	36.48
L12	0.68	33.09	3.54	35.69
L08	0.74	30.56	3.99	35.84
$LSD_{0.05}$	0.05	3.22	0.38	1.72
CV%	6.00	6.00	8.60	2.90

highest values for LAI and SPAD at both stages (Table 3). The reason for the higher values could be that the upper parts of KS2 and Tifton8 grew better than the other genotypes (field observation). For these genotypes, the residue parts (stem and leaves) could be useful after harvest for use as a green manure source for soil renovation.

3.3. Dry matter accumulation and nodule formation in peanut genotypes under drought and poor nitrogen conditions

Because of growth in the upper portions of the plants, dry matter accumulation should increase from the flowering stage to the pod filling stage. Moreover, Rhizobium bacteria in the nodules use energy produced during photosynthesis in leaves for nitrogen fixation, thus nodule number and nodule weight should also reach maximum values at the pod filling stage and then decrease afterward (Doan Thi Thanh Nhan et al., 1996). Our results followed the expected pattern and showed that the peanut genotypes reached the highest dry matter weight, nodule number, and dry weight at the pod filling stage. Among the peanut genotypes, KS2 was the best genotype with the highest values for all three traits (Table 4). These results are similar with those presented by Nguyen Thi Thanh Hai et al. (2010, 2015), Dinh Thai Hoang and Vu Dinh Chinh (2011), and Vu Dinh Chinh and Do Thanh Trung (2010) under non-stress conditions.

Table 4. Dry matter accumulation, nodule dry weight, and nodule number of peanut genotypes

Genotypes	Flowering stage			Pod filling stage		
	DM[1] (g/plant)	Nod. Number[2] (nod./plant)	NDW[3] (g/plant)	DM (g/plant)	Nod. Number (nod./plant)	NDW (g/plant)
Dau Giay	1.60	6.8	0.08	17.82	24.5	0.36
KS2	2.08	9.3	0.14	20.41	40.8	0.72
Tainan9	1.67	8.5	0.09	17.76	27.5	0.59
KKU60	1.63	4.0	0.07	14.39	28.5	0.67
D18	1.77	5.0	0.04	18.04	33.5	0.61
Tifton8	1.52	4.0	0.03	18.75	41.8	0.63
L12	1.74	7.8	0.03	16.31	39.0	0.41
L08	1.64	8.8	0.07	15.79	43.5	0.67
$LSD_{0.05}$	0.45	-	-	4.61	-	-
CV%	14.9	-	-	15.1	-	-

Note: [1]DM- dry matter accumulation; [2]Nod.number- nodule number, [3]NDW- nodule dry weight

Table 5. Infection rates of major diseases and insects of peanut genotypes

Genotypes	Leaf spot (Mark 1-9)*	Peanut rust (Mark 1-9)*	Leaf miner (%)	Black cut worm (%)
Dau Giay	1	1	10.1	0.8
KS2	3	3	11.2	0.7
Tainan9	3	1	9.4	0.4
KKU60	3	3	10.1	0.8
D18	1	1	12.2	0.3
Tifton8	3	1	8.6	0.5
L12	1	3	9.4	0.7
L08	3	1	9.0	0.5

*Note: *1- No infection, 9- Highly damaged*

3.4. Infection rates of major diseases and insects of peanut genotypes under drought and poor nitrogen conditions

All studied peanut genotypes were infected with at least one the main peanut diseases or insects at small rates (Table 5). Dau Giay and D18 had the lowest infection rates of both leaf spot and peanut rust diseases compared to the other genotypes. Tainan9, Tifton8, and L08 showed no peanut rust symptoms, but had minor leaf spot disease damage. Leaf miner insects damaged peanut leaves at the flowering stage with slight rates from 8.0 to 12.2%, whereas the black cut worms damaged leaves at the vegetative stage with very low rates (0.33-0.75%).

3.5. Yield components of peanut genotypes under drought and poor nitrogen conditions

Total pod number ranged from 7.0-12.8 (pods/plant) across all eight peanut genotypes tested. Among them, Tifton8 had the highest pods/plant, whereas KS2 had the lowest. KS2 also had the lowest values for seed rate and 100-seed weight, but the highest value for 100-pod weight. Tainan9 was the best genotype for rate of mature pods and 100-seed weight, whereas the highest seed rate genotype was Dau Giay (Table 6).

KS2 had strong growth of upper plant parts resulting in higher values for growth traits compared to the other genotypes. However, its ability to form and accumulate photosynthetic products into pods could be poor due to non-concentrated maturing, thus it had low values for mature pods, seed rate, and mature seeds. A similar experiment assessing peanuts under mid-season drought conditions in Thailand also showed that KS2 had lower total biomass as well as harvest index in comparison to Tainan9, KKU60, and Tifton8 (Dinh Thai Hoang *et al.*, 2013).

3.6. Pod yields and seed quality of peanut genotypes under drought and poor nitrogen conditions

The individual yield of the peanut genotypes ranged from 6.2 to 11.3 g/plant. Among them, D18 and Tainan9 were the best genotypes with the highest yields (11.3 and 11.0 g/plant, respectively). Dau Giay had the lowest individual yield value with only 6.2 g/plant. A similar result was found in total pod yield where D18 (21.5 quintal/ha) and Tainan9 (19.1 quintal/ha) were the best genotypes. All of the peanut genotypes had high lipid and protein contents which ranged from 18.8-20.8% and 51.7-54.3%, respectively. D18, KKU60, and Tainan9 were the genotypes with the highest lipid contents. Meanwhile, the genotype with the highest protein content was Tainan9, followed closely by KKU60 and D18 (Table 7).

Table 6. Yield components of peanut genotypes

Genotypes	Number of pods (pods/plant)	Rate of mature pods (%)	Seed rate (%)	100 pod weight (g)	100 seed weight (g)
Dau Giay	8.0	91.7	75.6	98.7	44.0
KS2	7.0	85.8	64.4	162.2	39.6
Tainan9	12.8	92.0	71.2	116.2	55.8
KKU60	10.3	85.5	71.4	104.6	41.8
D18	10.0	84.0	67.9	139.0	41.2
Tifton8	11.5	87.1	66.3	102.2	41.1
L12	8.9	82.3	68.1	115.3	45.3
L08	9.7	79.5	70.9	97.2	42.3
$LSD_{0.05}$	0.86	-	-	-	-
CV%	2.10	-	-	-	-

Table 7. Pod yield, lipid and protein content in seed of peanut genotypes

Genotypes	Individual yield (g/plant)	Total pod yield (quintal/ha)	Lipid content (%)	Protein content (%)
Dau Giay	6.2	12.5	19.3	53.3
KS2	7.7	13.7	19.7	53.5
Tainan9	11.0	19.1	20.2	54.3
KKU60	6.6	13.1	20.5	53.9
D18	11.3	21.5	20.8	53.8
Tifton8	7.0	14.3	18.8	51.7
L12	8.0	17.3	19.3	52.8
L08	6.6	13.7	20.0	52.2
$LSD_{0.05}$	-	0.86	-	-
CV%	-	7.50	-	-

4. CONCLUSIONS

Studied peanut genotypes showed variation in growth, yield, and seed quality under drought and poor nitrogen conditions. Peanut genotypes, including Tainan9, D18, Tifton8, and L12 had high germination rates (>90%) and high tolerance to major pestilent insects under drought and poor nitrogen conditions in comparison with the control variety, Dau Giay. D18 and Tainan9 were the best genotypes with the highest yields. These genotypes and KKU60 were also high seed quality genotypes with high lipid and protein contents. These results suggest that the D18 and Tainan9 genotypes have the potential for high yield and seed quality under artificial drought conditions. It is necessary to continue research under field conditions in real drought and poor nutrient areas to firmly demonstrate these genotypes's effects on peanut production in Vietnam.

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REFERENCES

Vu Dinh Chinh, Do Thanh Trung (2010). Effect of fertilizer on growth development and yield of peanut at Viet Yen - Bac Giang. J. Sci. Dev., 8(3): 367-374.

Nguyen Thi Thanh Hai, Vu Dinh Chinh, Dinh Thai Hoang (2010). Evaluation of growth, development, yield and preliminary combining ability test of some superior peanut lines and varieties. J. Sci. Dev., 8(3): 375-383.

Nguyen Thi Thanh Hai, Vu Dinh Chinh (2011). Evaluation on agronomical characters of groundnut varieties grown in spring and autumn seasons at Gia Lam - Hanoi. J. Sci. Dev., 9(5): 697-704.

Dinh Thai Hoang, Wanwipa Kaewpradit, Sanun Jogloy, Nimitr Vorasoot, Anan Patanothai (2014). Nutrient uptake of peanut genotypes with different levels of drought tolerance under mid-season drought. Turkish Journal of Agriculture and Forestry, 38: 495-505.

Dinh Thai Hoang, Wanwipa Kaewpradit, Sanun Jogloy, Nimitr Vorasoot, Anan Patanothai (2013). Biological nitrogen fixation of peanut genotypes with different levels of drought tolerance under mid-season drought. SABRAO Journal of Breeding and Genetic, 45 (3): 491-503.

Dinh Thai Hoang, Vu Dinh Chinh (2011). Effect of plant density on growth and yield of TB25 groundnut cultivar in spring season at Gia Lam - Hanoi. J. Sci. Dev., 9(6): 892-902.

Htoon, W., S. Pimratch, S. Jogloy, N. Vorasoot, B. Toomsan, and A. Patanothai (2012). Nutrient uptake of peanut genotypes under different water regimes. Annual Technical Seminar 2012 CHE-TRF-KKU Distinguished Research Professor Project of Professor Dr. Aran Patanothai, May 26-

27, 2012. Sirindhorn Dam, Ubon Ratchathani, Thailand.

Http://www.cand.com.vn/news/97_99873_tay-nguyen-ha-n-ha-n-nga-y-ca-ng-kho-c-lie-t.aspx (24/7/2013)

Http://www.sonongnghiep.daklak.gov.vn/lt.aspx?cid=0&pg=30

Kjeldahl, J. (1883). New method for the determination of nitrogen in organic substances. Zeit. Anal. Chem., 22: 366-383.

Ministry of Agriculture and Rural Development (2010). 575 new agricultural varieties. Publisher of Agriculture, Hanoi.

Ministry of Agriculture and Rural Development (2011). National Technical Regulation on Testing for Value of Cultivation and Use of Groundnut varieties. QCVN01-57:2011/BNNPTNT.

Doan Thi Thanh Nhan, Nguyen Van Binh, Vu Dinh Chinh, Nguyen The Con, Le Song Du, Bui Xuan Suu (1996). Textbook of industrial crops.Publisher of Agriculture, Hanoi, pp. 46-56.

Nageswara Rao, R.C., S. Singh, M.V.K. Sivakumar, K.L. Srivastava, and J.H. Williams (1985). Effect of water deficit at different growth phases of peanut. I. Yield responses. Agronomy Journal, 77: 782-786.

Patil, B.P., and S.B. Gangavane. (1990). Effects of water stress imposed at various stages on yield of groundnut and sunflower. Journal of Maharashtra Agricultural University, 15: 322- 324.

Pimratch, S., S. Jogloy, N. Vorasoot, B. Toomsan, A. Patanothai, and C.C. Holbrook (2008a). Relationship between biomass production and nitrogen fixation under drought stress conditions in peanut genotypes with different levels of drought resistance. Journal of Agronomy and Crop Science, 194: 15-25.

Puangbut, D., S. Jogloy, N. Vorasoot, C. Akkasaeng, T. Kesmala and A. Patanothai. (2009). Variability in yield responses of peanut (*Arachis hypogaea* L.) genotypes under early season drought. Asian Journal of Plant Sciences, 8: 254-264.

Soxhlet, F. (1879). Dinglers' Polyt. J., 232: 461.