Indonesian Peanut Cultivar Difference in Yield Performance Based on Source and Sink Characteristics**

ISKANDAR LUBIS*[1], Heni Purnamawati[1], Roedhy Poerwanto[1], Yudiwanti[2],
Ahmad Ghozi Mansyuri[3], Sri Astuti Rais[4] and Tatsuhiko Shiraiwa[5]
([1] Lab. of Crop Prod., Bogor Agric. Univ., [2] Lab. of Plant Breed., Bogor Agric. Univ., [3] Legume and Tuber Crops Res.Cent., Indonesian Dept of Agric., [4] Agric. Gen. Res.and Biotech. Res. and Dev. Cent., Indonesian Dept. of Agric. and [5] Lab of Crop Sci., Kyoto Univ.)

Peanuts productivities in Indonesia during the last 17 years (1986 – 2003) were between 0.7 to 1.2 ton/ha dry seeds (Kasno, 2004), although some new varieties that have yield potential 2.0 to 2.5 ton/ha or more have been released, however farmers' productivity could reach only 50 – 60% of the yield potentials. This research was conducted to clarify cultivar differences in sink and source size as represented by vegetative growth and yield, and as a part of serial research that aimed to increase peanut productivity in Indonesia by better understanding of yield formation in peanut.
Experiments were conducted at Bogor Agricultural Universities' farms, Sawah Baru and Cikarawang (06^{o}33', S, 106^{o}45', 250m altitude). Planting started on June 12 and June 20, 2007, respectively using 20 local and national cultivars in each location. Design of experiments are randomized complete block with three replications, and advanced analysis by Tuckey with 5% reliance. Size of experimental unit was (1.6 x 4) m, with planting density 125 000 plants/ha. Urea, SP36 and KCl applied at planting date in the dossage of 45 kg N, 100 kg P_2O5 and 50 kg K_2O per ha.
Destructed sampling was done four times, namely T1, 25 days after transplanting (DAT); T2, 6 weeks after transplanting (WAT); T3, 10 WAT (grain filling) and T4, 14 WAT (harvest). Five plants sampled in T1, two plants in T2, T3 and T4, and separated into leaves, stems, roots and pods. Leaf area measured with gravimitri method before it was oven dried together with other sample parts in 60^{o}C during 3 days. Harvest was done at 14 WAT, from two middle rows of experimental unit (5 plants), and separated to pods and stems and leaves, wegihted, and then pods were air dried for 3-5 days.
From average yield of two stations, it showed that Cultivar Biawak reached the highest yield due to relatively higher aboveground dry weight (source), filling percentage and maximum number of gynophor+pods (potensial sink). While Cultivar Jepara had the lowest yield due to low filling percentage and potential sink, although its source counted as a medium categories (Table 1). Based on relationship between aboveground dry weight and seed yield, 20 cultivars used could be devided into three groups, namely 1. more efficient source utilization (R^2=0.85), 2. less efficient source utilization (R^2=0.54) that may indicating ineficiency in soure utilization and 3. Extraordinary high source (Figure 1.). Grouping also canbe made based on relationship between potensial sink and seed yield (Figure 2), which are 1. more efficient in potensial sink utilization (R^2=0.61), 2. less efficient in potential sink utilization that may indicating ineficiency in sink formation (R^2=0.65) and 3. Extraordinary high potensial sink. If we look at Figure 3 which drawed the relationship between filling percentage and seed yield, it showed two different groups, more efficient in pod filling that may indicating the lack of source or obstacle in assimilate partitiong to the pods during grain filling in the first groups (R^2=0.65), while the second group less efficient in pod filling that may indicating in effisiensi in pods (sink) produced from gynophor+ pods (potential sink) (R^2=0.47). These results are in agreement with Duncan et.al (1978), who explained that variation among four peanuts cultivar with runner and stand up type in America were due to three physiological processes namely assimilate partitioning between vegetative and reproductive, grain filling period and velocity and synchronization of pod formulation.
From these results we conclude that there are cultivar differences in partitioning of assimilates and pod formulation characteristics among 20 Indonesian peanut cultivars and this affected seed yield performance.

** This research is funded by Research and Development Beaureau, Indonesian Department of Agriculture.

INTRODUCTION

Peanuts productivities in Indonesia during the last 17 years (1986 – 2003) were between 0.7 to 1.2 ton/ha dry seed (Kasno, 2004; Deptan 2004), although some new varieties that have yield potential 2.0 to 2.5 ton/ha or more have been released, however farmers' productivity could reach only 50 – 60% of the yield potentials.

Problems that often occur in the field are low filling percentage that resulting empty pod or small seed size which is lower than maximum size that can be reached. Bell and wright (1998) found that peanuts produktivities in Indonesia were low due to low filling percentage, although population is high density. This fact indicate lower assimilate partitioning to the grain.

Peanuts that cultivated in Indonesia, commonly are indeterminate type which vegetative organ continiuisly growth, although generative phase of growth has started. This fact affect partitioning pattern of assimilate and as a cosequency assimilate that can be transported to the grain decrease.

Source and sink relationship are determined by capacity and activity of photosynthesis (source) and capacity, activity and competetion among sinks. Crop yield is determined by the amount of dry matter accumulation and its' partitioning or harvest index (Egli, 1999). Increasing yield can be reached either through increasing dry matter accumulation and or increasing harvest index (Evans and Fischer, 1999).

Duncan et.al (1978) explained that variation among four peanuts cultivar with runner and stand up type in America were due to three physiological processes namely assimilate partitioning between vegetative and reproductive, grain filling period and velocity and synchronization of pod formulation. Moreover, Ketring et.al. (1982) said that peanuts characteristic that determined yield were pod numbers, assimilate partitioning during grain filling, and grain filling period.

Many researchs showed that dry matter accumulation immediatly before and at grain filling period determine the yield. Shiraiwa et.al. (2004) found that the amount of dry matter accumulation at early period of grain filling phase was determined yield differences among soybean genotypes. The differences between high yielding and low yielding rice were depended on capacity of dry matter accumulation before heading and assimilate translocation during grain filling (Miah et.al., 1996). While Lubis et.al. (2003) stated that yield was more affected by rice dry matter at grain filling than non structural carbohydrate (NSC) at heading.

Longevity and capacity of leaf photosynthesis is related with N status in the leaf. two sources of N for seed growth during grain filling phase mainly N that absorbed by root, and remobilisation from vegetative organ (Ta and Weiland, 1992). Delay of leaf N remobilisation can maintain photosynthetic capacity more longer, and probably can inrease seed yield. Leaf area index also affect the capacity of crop photosynthesis and can be used as an indicator for period of leaf greeness. Dale et.al. in Edoka (2006) stated that leaf area index determine amount of solar radiation that could be absorbed by the canopy, and then affect photosynthesis, assimilate translocation and yield.

Many researchers have observed dominant characters that determine peanut yield, such as canopy development, partitioning coefficient, grain filling period, velocity of pod formulation, number of pod and seed size (Duncan et.al., 1978; Mc Cloud et.al., 1980; Ketring et.al., 1982; Indradewa, 1988), however there are no much information about how the peanut fulfill the assimilate requirement during grain filling.

This research is aimed to clarify cultivar differences in sink and source size, as represented by vegetative growth and yield, and as a part of serial research that aimed to increase peanut productivity in Indonesia by better undestanding of yield formation in peanut.

METHODOLOGY

Experiments were conducted at Bogor Agricultural Universities' farms, Sawah baru and Cikarawang (06^{o}33', S, 106^{o}45', 250m altitude). Planting started on June 12 and June 20, 2007, respectively using 20 local and national genotypes in each location. Desain of experiments are randomized complete block design with three replications, and advanced analysis by Tuckey with 5% reliance.

Soil was analized before transplanting, using 1 kg soil from up to 15 cm depth of soil sample which was mixed from each replication in soil laboratory, department of land resources and soil science, Faculty of Agriculture, Bogor Agricultural University.

Size of experimental unit was (1.6 x 4) m, with planting density 80 plants per unit or 40 x 20 cm, with 2 seeds per hole, and remain one seed per hole after one week, which is about 125 000 plants/ha. Urea, SP36 and KCl applied at planting date in the dossage of 45 kg N, 100 kg P_2O5 and 50 kg K_2O per ha.

Sampling method

Destructed sampling was done four times, namely T1, 25 days after transplanting (DAT); T2, 6 weeks after transplanting (WAT); T3, 10 WAT (grain filling) and T4, 14 WAT (harvest). Five plants sampled in T1, two plants in T2, T3 and T4, and separated into leaves, stems, roots and pods. Leaf area measured with gravimitri method before it was oven dried together with other sample parts in 60^{o}C during 3 days and weighted, then prepared for N and Non-structural carbohydrate (NSC) analysis.

Photosynthesis and traspiration was measured in the sampling time using Gas Exchange System LCA-4 (ADC Bio-Scientific) at 08.00 to 10.00 a.m. for photosynthesis, and at 19.00 p.m.

for respiration in two plants at T2 and T3 in Cikarawang experimental station. Two leaves from the third joint of primary branch sampled in T2 and T3 at 08.00 – 09.00 a.m. for chlorophyl measurement.

Harvest was done at 14 WAT, from two middle rows of experimental unit (5 plants), and separated to pods and stems and leaves, wegihted, and air dried for 3-5 days. After drying, seeds was taken from the pods and again air dried until 8% water content. Productivity and its components were measued as Number and weight of pods, Filled and unfilled pod numbers, 100 seeds weight, ratio seed with pood and harvest index.

Oven dried leaf and stem of 8 genotypes that has specific sink-source balance were analyzed for N and NSC contents in Food Services Laboratorium of Food Technology Department, Faculty of Agriculrtural Mechanization and Technology, Bogor Agricultural University. Total Non-structural Carbohydrate (TNC) was adjusted from proximat and crude fiber, while N was analyzed by Kjeldahl method.

RESULT AND DISCUSSION

General Condition

Soil analysis result showed that there was no much difference in soil fertillity of two experimental stations, however soil in Sawah Baru station was more solid than cikarawang station, and it had little bit difficulties in land preparation and transplanting. Moreover, the irrigation system in Sawah baru was broken after transplanting, and its repairment took 3 weeks, and as a consequency growth of peanuts in the early season were disturbed, especially in one replication. Weed controle was done manually in 3 and 5 WAT, while pest control was controlled once a week using insecticide and fungicide from five WAT to two weeks before harvest.

20 cultivars used in the experiments have various characteristics, and could be devided into: 1) small grain cultivars (< 40 mg) such as Panter, Turangga, Rusa, Badak, Zebra and Kelinci; and 2) big grain cultivars (> 40 mg) such as Biawak, Kancil, Gajah, Jepara, Garuda 3, Sima, Garuda 2, Kidang, Macan, Mahesa, Pelanduk, Simpai, Landak, dan Jerapah. These cultivars can also be devided into two seeds and three seeds per pod cultivars, where the three seeds per pod culativars are Panter, Turangga, garuda 3, Sima, Jerapah and Kelinci (Table 1).

Yield Performance

From average yield of two stations, it showed that cultivar Biawak reached the highest yield due to relatively higher above ground dry weight (potential source), filling percentage and maximum number of gynophor + pods (potential sink). While cultivar Jepara had the lowest yield due to lower filling percentage and potential sink, although its potential source counted as a medium categories (Table 2).

Yield in relation with Source and Sink

The relationship between yield and aboveground dry weight showed cultivar differences in respons of yield to aboveground dry weight (Figure 1). The twenty cultivars used can be divided into three groups namely: 1) more efficient of source utilization (R^2=0.85); 2) less eficient of source utilization (R^2=0.54) and 3) extraordinary high sources.

Cultivar differences also showed in relation between yield and maximum numbers of gynophor and pods (Figure 2). Three groups also can be made based on this relationship, namely: 1) more efficient in potential sink utilization (R^2=0.61); 2) less efficient in potential sink utilization (R^2=0.65) and 3) extraordinary high potential sink.

Figure 3 which drawed the relationship between filling percentage and seed yield distinguished two different groups, more efficient in pod filling that may indicating the lack of source or obstacle in assimilate partitiong to the pods during grain filling in the first groups (R2=0.65), while the second group less efficient in pod filling that may indicating in effisiensi in pods (sink) produced from gynophor+ pods (potential sink) (R2=0.47).

The groups of cultivars can be tabulated based on those three relationships in order to see the consistency of cultivars in potential source and or potential sink utilization (Table 3). It showed that cultivar Biawak, Garuda 2 and Jerapah are consistent more efficient in potential source and sink utilization, and pod filling. In the other hand, cultivar Kancil is less efficient in potential source and sink utilization, and pod filling. While cultivar Turangga and Sima are extraordinary have high potential sources, and cultivar Zebra has extraordinary high potential sink.

Yield and Pod Formation

Peanut pod number per square meter increased from T2 to T4 (Table 4). Number of pod ranged from 7.3 per m^2 of Jerapah to 86.5 per m^2 of Kelinci at T2, from 117 per m^2 of Mahesa and Badak to 237.5 per m^2 of Biawak at T3, and from 191.7 per m^2 of Badak to 368.8 per m^2 of Rusa at T4. The relationship between pod number with yield showed that number of pod per square meter at T3 has closer relationship (R2=0.264) than the relationship of umber of pod at T2 (R2=0.046) or T4 (R2=0.091). This fact may indicating that number of pod at T3 is one of important factors that related with yield formation. Many of pod that formed during T3 – T4 may not supplied with enough assimilate during grain filling due to their late formation, while number of pod that formed at T2 may not appear the through number of final pod.

Yield and Dry Matter Production

Except cultivar Turangga and Sima that have extraordinary high aboveground dry weight, it was showed a slightly relationship between dry matter production during reproductive stage (T2 to T4) with yield (R^2=0.25) (Figure 4). It may indicating that dry matter production during reproductive stage is not only the factor that contribute to the yield performance.

When aboveground growth rate is drawn with Yield, it indicated that some cultivars such as Biawak, Landak, Gajah and Jerapah may utilize non structural carbohydrate that remobilize from aboveground part to the pods, because they have negative aboveground growth rate during grain filling (T3 – T4), while the other cultivars such as Sima, Simpai and Garuda 2 may only depended on photosynthesis during grain filling (Figure 5).

Crop Growth Rate in relation to Pod Number and Aboveground Dry Weight

Relationship among crop growth rate and number of pods showed that the relationship between CGR during T2-T3 and number of pods at T3 was more closer than the relationship between CGR T1-T2 and number of pods at T2 or relationship between CGR T3-T4 and number of pods at T4 (Table 5). According to the closer relationship of number of pod at T3 to the yield, the closer relation of CGR during T2-T3 to the number of pod at T3 may indicating the important contribution of CGR during T2-T3 to the yield performance.

Table 5 can also show that aboveground dry weight at T2 and T3 has close relation with CGR during T1 – T2 and T2 - T3 than the relationship of aboveground dry weight at T4 with CGR during T3 – T4. Considering the possibility of assimilate remobilization during grain filling and the role of dry matter production during grain filling to the yield performance, this fact may strengthen the indication of that crop growth rate during T2 – T3 may have significant contribution to the yield perfoemance.

Crop Growth Rate in relation to Leaf Area Index and Single Leaf Photosynthesis

From the above results, it showed that CGR during T2-T3 has valuable influence to the yield through number of Pods at T3 and aboveground dry weight at T3. In order to examine the factors that related with CGR during T2-T3, CGR was Correlated with average LAI and Single leaf photosynthesis.

It was showed that the closest relationship occurred between average LAI and CGR during T2-T3 (R2=0.73) compared to their relationships at T1-T2 (R2= 0.57) and T3-T4 (0.03) (Table 6).

The closed relationship between CGR and LAI during T2-T3 may indicating the important role of LAI during this period in contribution to yield performance.

Referrences

Bell, M.J. and G.C. Wright. 1998. Groundnut growth and development in contrasting environment. 1. Growth and plant density responses. Experimental Agriculture 34 : 99-112.

Duncan, W.G., D.E. McCloud, R.L. McGraw and K.J. Boote. 1978. Physiological aspects of peanut yields improvement. Crop Science 18 : 1015 – 1020.

Edoka, P.N. 2006. Influence of Leaf Area Development of Early and Mid-early Maturity Varieties of silage Maize on Dry Matter yield and Forage Quality. Dissertation. Institut Fur Planzenbauwissenschaften, Lanswirtschaftlich-Gärtnerische Fakultät, Humboldt Universität zu Berlin.

Egli, D.B. 1999. Variation in leaf starch and sink limitation during seed filling in soybean. Crop Sci. 39 :1361-1368

Evans, L.T. and R.A. Fischer. 1999. Yield Potential: its definition, measurement and significance. Crop Sci. 39:1544-1551

Gifford, R.M. and L.T. Evans. 1981. Photosynthesis Carbon Partitioning and Yield. Ann. Rev. Plant Physiol. 32:485-509.

Indradewa D. 1986. Dasar-dasar Fisiologis Peningkatan Hasail Kacang Tanah. Makalah pada Kongres III dan Seminar Nasional Agronomi Perhimpunan Agronomi Indonesia, Jakarta. 11hal.

Kasno, A. 2005. Profil dan Perkembangan Teknik Produksi Kacang Tanah di Indonesia. Seminar Rutin Puslitbang Tanaman Pangan Bogor.

Ketring, D.L., R.H. Brown, G.A. Sullivan and B.B Johnson. 1982. Growth Physiology. *In* H.E. Pattee and C.T Young (Ed.) Peanut Science and Technology. American Peanut Research and education Society, Inc.

Lubis, I., T. Shiraiwa, M.Ohnishi, T.Horie and N. Inoue. 2003. Contribution of sink and source sizes to yield variation among rice cultivars. Plant Prod.Sci. 6(2):119-125

Mc Cloud, D.E., W.G. Duncan, R.L. Mc Graw, P.K. Sibale, K.T. Ingram, J. Dreyer and I.S. Campbell. 1980. Physiological Basis for Increased Yield Potential in Peanuts. *In* Proceedings of The International Workshop on Groundnuts. ICRISAT Center. Patancheru. 125 pp.

Miah, M.N.H., T. Yoshida, Y. Yamamoto and Y. Nitta. 1996. Characteristics of dry matter production and partitioning of dry matter in high yielding semi dwarf indica and japanica-indica hybrid rice varieties. Jpn. J.Crop.Sci. 65:672-685.

Senoo, S. And A. Isoda. 2003. Effects of paclobutrazol on dry matter distribution and yield in peanut. Plant Production Science vol. 6:90-94.

Shiraiwa, T., N. Ueno, S.Shimada and T. Horie. 2004. Correlation between yielding ability and dry matter productivity during innitial seed filling stage in various soybean genotypes. Plant Prod. Sci. 7(2):138-142.

Ta C.T. and R.T. Weiland. 1992. Nitrogen partitioning in maize during ear development. Crop Sci. 32:443-451

Mc Cloud, D.E., W.G. Duncan, R.L. Mc Graw, P.K. Sibale, K.T. Ingram, J. Dreyer and I.S. Campbell. 1980. Physiological Basis for Increased Yield Potential in Peanuts. *In* Proceedings of The International Workshop on Groundnuts. ICRISAT Center. Patancheru. 125 pp.

Miah, M.N.H., T. Yoshida, Y. Yamamoto and Y. Nitta. 1996. Characteristics of dry matter production and partitioning of dry matter in high yielding semi dwarf indica dan japanica-indica hybrid rice varieties. Jpn. J.Crop.Sci. 65:672-685.