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# Vegetative and generative growth of groundnut genotypes under biotic environmental stress

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**Abstract.** *Rahmianna AA, Yusnawan E. 2016. Vegetative and generative growth of groundnut genotypes under biotic environmental stress. Biodiversitas 17: 503-509.* The decrease in groundnut pod yield is mainly influenced by disease infestation, especially bacterial wilt and foliar diseases. The objectives of this experiment were to determine the response and tolerance of groundnut genotypes to bacterial wilt, leaf spot and rust diseases, and seed infection by *Aspergillus flavus*. The planting materials were 25 genotypes (11 Indonesian cultivars, 12 lines introduced from ICRISAT, 1 Indonesian promising line, and 1 local cultivar) with various superiorities on diseases resistance. This study was arranged in a randomized completely block design with triplicate. The results indicated that both genotypes from ICRISAT and Indonesia had similar response to leaf spot i.e. ranging from susceptible (score 6-7) to highly susceptible (8-9). The score for rust ranged from moderately resistant to susceptible. The average pod yield was 23.1 g/plant (from 11.9 g to 29.5 g), and 13 and 12 genotypes produced pods higher and lower than the average value, respectively. ICGV 86158 and ICGV 95322 had the highest and lowest seeds as well as pod productivity, respectively. The ICRISAT genotypes were susceptible to *Ralstonia solanacearum* infection, except for ICGV 86590. Among the Indonesian cultivars, those with Valencia type of growth, relatively had better resistance to bacterial infection. These cultivars were also resistant to rust and *A. flavus* infection.

**Keywords:** Biotic stress, generative, groundnut, vegetative performance

## INTRODUCTION

The national productivity of groundnut in Indonesia was lower compared to the world production, and even lower compared to China, Argentina, USA, and Australia, which are the main groundnut production countries in the world. The productivity was considered to be low because a number of constraints both abiotic and biotic factors. The major biotic factors limited pod yields are pests, diseases and weeds. Among these factors, the reduction of pod yield of groundnut in Indonesia is mainly influenced by disease infection, especially bacterial wilt and foliar diseases.

The most prevalent foliar diseases in Indonesia are late leaf spot and rust caused by *Cercospora arachidicola* (*Phaeoisariopsis personata*) (Berk & M.A. Curtis) van Arx, and *Puccinia arachidis* Speg., respectively (Mehan and Hong 1994). The infection of *P. arachidis* is able to reduce to 60% of groundnut pod yield. The same figure also occurs when the crop is infected by *C. arachidicola* or *Cercosporium personatum* (Thakur et al. 2013). When rust and leaf spot infect together, there will be 50-70% pod yield reduction. Instead of pod yield, these diseases also reduce kernel quality and produce severe damage of the foliage.

Bacterial wilt caused by *Ralstonia solanacearum* has been becoming serious yield limiting factor for groundnut production since ten of years ago in Indonesia. This incidence was firstly reported in year 1905 at Cirebon region, West Java. The yield loss due to Ralstonia bacterial wilt was 15-35% for resistant variety, and 60 to 100% for susceptible variety grown in endemic area with high infection (Machmud and Rais 1994; Nugrahaeni and Purnomo 2013).

*Aspergillus flavus* is a saprophytic fungi that produces secondary metabolite called aflatoxin under unfavorable environment. This toxin is very harmfull to human health as of its carcinogenic, teratogenic and immune suppressive which causes liver cancer to human and early death to cattle, duck and chicken.

The important role of foliar diseases and bacterial wilt on the success of groundnut production was noted since early phase of breeding works in Indonesia in 1950's. Instead of high pod yield, the resistance status of these diseases had been included as the main parameters in developing new varieties. The journey of breeding works since then until recently, has been consistently put those three important diseases into the main parameter in developing new varieties despite the additional parameters especially from the abiotic factors such as tolerance to suboptimal soil conditions (acid soil with and without high Aluminum saturation, tidal swamp areas, dry areas and dry season cropping, wet/waterlogged condition left after wetland rice, drought during generative growth phase, suitability to multiple cropping, and shading tolerance, as well as alkaline soils with high iron (Fe) content and high pH. Since the last 15 years, another biotic factor i.e. the tolerance status to *A. flavus* infection has been considering as an important aspect (Wahyar et al. 2015).

Due to the important status of those diseases to groundnut crops and its pod yield, the experiment was aimed to determine the response as well as the tolerance of groundnut genotypes to bacterial wilt, leaf spot and rust diseases, and seed infection by *A. flavus* under wet condition in developing-central production areas.

## MATERIALS AND METHODS

The experiment was conducted at the farmer's field in dryland area at Central Java Province, Indonesia during wet season from January to May. In this region, groundnut is grown once a year intercropped with cassava where cassava is grown 3-4 weeks after groundnut sown. A total of 25 genotypes with various superiorities especially on diseases resistance, were grown under rainfed condition. The planting materials consisted of 11 Indonesian improved cultivars, 12 lines (ICGV's, IC and J) obtained from International Center for Research Institute for Semi Arid Tropic (ICRISAT), 1 Indonesian promising line, and 1 local cultivar (Table 1).

This study was arranged in a randomized completely block design with triplicate. Each genotype was planted in a 12 $m^2$ plot with plant spacing of 40 x 15 cm, and 1 plant was maintained in every hole. The basal fertilizers of 22.5 kg N, 36 kg $P_2O_5$ and 50 kg $K_2O$ $ha^{-1}$ were applied just after sowing by broadcasting the fertilizers in the furrow along the row. The dosage of 1000 kg farmyard manure and 500 kg lime $ha^{-1}$ were incorporated into the soil during land cultivation. Weeding was conducted twice, i.e. at 25 and 59 days after sowing (DAS). Insecticides were applied at 15, 22, 40, and 50 DAS. *A. flavus* inoculation was conducted to guarantee the presence of abundant population in the *geocarphosphere*. The inoculation was conducted at 55 DAS along the plant's rows. Meanwhile, leaf spot and rust incidence merely depend on the natural infection. Water irrigation was intermitted at 60 DAS then the soil was left drying out until harvesting time at 90 DAS. Harvesting was undertaken when 75% of the filled pods had already matured. The pods then immediately separated from the plants, and sun dried. The observations were undertaken on agronomic parameters (plant height, haulm weight, 100 seed weight, filled pod number, empty pod number, and pod yield/plant), and number of plants at harvesting time (the plants that survived/interference from bacterial wilt infection), the incidence of leaf spot and rust, and *A. flavus* infection on the seeds. The bacterial wilt incidence was observed by counting the number of wilted plants every 2 weeks and expressed as percentage of wilted plants to its full population. The resistance criteria was rated according to Machmud and Rais (1994) that resistant (R) genotypes with ≤15% wilt incidence; moderately resistant (MR) with 16-25% wilt incidence; moderately susceptible (MR) with 26-35% wilt incidence, and susceptible (S) with >35% wilt incidence. Assessment on the severity of leaf spot and rust diseases were scored at 85 DAS using 1-9 scale developed by Subrahmanyam et al. (1995), where 1 = no disease and 9 = plants severely affected. The percentage of kernels infected by *A. flavus* was determined by plating 100 kernels per sample onto the *A. flavus* and *parasiticus* agar (AFPA) media in 10 petri

**Table 1.** List of genotypes and their characteristics used as planting materials. Banjarnegara, wet-early dry season (February-May)

| Genotype | Remarks |
|---|---|
| ICRISAT lines | |
| ICGV 86158 | Fresh seed dormancy |
| ICGV 93291 | Short duration |
| ICGV 95322 | Short duration |
| ICGV 86590 | Resistant to rust and tolerant to leaf spot, a released cultivar in India |
| J 11 | Resistant to in vitro seed colonization by *A. flavus* |
| ICGV 93280 | Resistant to in vitro seed colonization by *A. flavus* |
| ICGV 95494 | Tolerant to in vitro seed colonization by *A. flavus* |
| ICGV 99029 | Large seed, suitable for confectionery uses |
| IC 48 | Tolerant to drought |
| ICGV 91278 | Tolerant to drought |
| ICGV 91284 | Short duration |
| ICGV 89104 | Tolerant to pre-harvest seed infection by *A. flavus* |
| Indonesian cultivars | |
| Anoa | Resistant to wilting caused by *R. solanacearum*; resistant to rust and leaf spot |
| Bima | Moderately resistant to wilting caused by *R. solanacearum*; susceptible to rust and moderately susceptible to leaf spot |
| Bison | Moderately resistant to rust, leaf spot and seed infection by *A. flavus*; Tolerant to 25% shading; tolerant to Fe shortage and adapted in alkaline Alfisols |
| Jerapah | Resistant to wilting caused by *R. solanacearum*; resistant to rust and leaf spot; tolerant to drought, tolerant to acidic soil condition |
| Kelinci | Moderately resistant to wilting caused by *R. solanacearum*; resistant to rust and leaf spot |
| Komodo | Resistant to wilting caused by *R. solanacearum*; susceptible to PSTV; suitable to drylands; dry season planting |
| Kancil | Resistant to wilting caused by *R. solanacearum*; tolerant to rust, leaf spot, and seed infection by *A. Flavus* |
| Panter | Resistant to wilting caused by *R. solanacearum*; tolerant to rust, leaf spot, drought, broad adaptation |
| Singa | Tolerant to wilting caused by *R. solanacearum*; resistant to rust and moderately resistant to leaf spot, tolerant to drought, broad adaptation |
| Turangga | Resistant to wilting caused by *R. solanacearum*; moderately resistant to rust, leaf spot, seed infection by *A. flavus*, drought and shading |
| Zebra | Tolerant to rust and leaf spot, suitable to wet and dry lands |
| Indonesian promising line | |
| GH 51 | Tolerant to drought; Moderately susceptible to rust, leaf spot and wilting caused by *R. solanacearum*; low aflatoxin contamination; resistant to pre-harvest seed infection by *A. flavus* |
| Local variety | |
| Lamongan | Tolerant to drought |

dishes (as replications) or 10 seeds per each petri dish. The seeds were incubated for 3 days when the fungal infection was easily identified i.e. by the presence of dark yellow or orange color fungal colonies on the seeds. The number of seeds with yellow fungal colony was recorded. All the data obtained were subjected to analyses of variance (Anova), the significance of treatment differences was found out using Duncan's Multiple Range Test at 5% level of probability.

## RESULTS AND DISCUSSION

### Vegetative growth

Plant height and fresh haulm (above ground biomass) weight were two parameters that were mostly used to express the performance of vegetative growth of the crop. These two parameters were significantly different among genotypes tested. Plant height of those genotypes varied from 25.1 cm to 56.1 cm with 35.3 cm in average (Table 2). As many as 17 genotypes were shorter and eight genotypes were taller than the average height. In addition, fresh haulm weight ranged from 25 g to 91.7 g (Table 2), with average weight was 56.2 g, where 13 and 12 genotypes had lower and higher weight than the average value, respectively.

Both genotypes from ICRISAT and Indonesia had similar response to leaf spot i.e. ranging from susceptible (score 6-7) to highly susceptible (8-9). In connection to rust disease, the score ranged from moderately resistant to susceptible (Table 3). The score of leaf spot disease was higher compared to that of rust disease in all genotypes tested, as leaf spot incidence was more prominent during wet season that last from October to April.

### Generative growth

The average pod productivity (pod yield per plant) was 23.1 g with the lowest and highest values were 11.9 g and 29.5 g, respectively. A total of 13 and 12 genotypes produced pods higher and lower than the average value, respectively. In terms of seed yield per plant, the highest and lowest yields were 19.0 g and 6.9 g, respectively with 14 genotypes gave higher seed yield and 11 genotypes gave lower seed yield than the average, i.e. 13.3 g. ICGV 86158 and ICGV 95322 had the highest and lowest seed as well as pod productivity, respectively (Table 4). Contrary to vegetative growth, pod and seed yields per plant of all genotypes did not significantly different.

Singa cultivar which was superior in its vegetative growth (plant height and fresh haulm weight) was not followed by the highest pod yield, number of filled pods, and seed weight of individual plant. These components were less superior compared to those of ICGV 86158 which produced highest pod yield of individual plant (29.1 g). This success was supported by high values of the yield components i.e. seed yield per plant, number of mature pods per plant, and shelling outturn (Table 4). These results were in agreement with the finding of Padmaja et al. (2013) for seed yield per plant, number of mature pods per plant.

The study revealed correlations between leaf spot and the number of filled pods, shelling outturn, and seed yield. Pod yield, separately, correlated to plant height, fresh haulm weight, number of filled pods, and seed yield. The direct correlation of leaf spot and seed yield was reported by Thakur et al. (2013). Meanwhile, rust disease correlated to the number of filled pods only (Table 5). Despite the presence of correlation to vegetative and yield components, these two diseases did not correlate to pod yield. This is in agreement of the findings of Padmaja et al. (2013) who noticed the negative indirect effect of leaf spot to pod yield via number of mature pods per plant and hundred seed weight.

**Table 2.** Vegetative components of 25 peanut genotypes grown at dryland. Banjarnegara, wet-early dry season (February-May)

| Genotype | Plant height (cm) | Fresh weight of haulm (g/plant) |
|---|---|---|
| Local Lamongan | 34.0 de | 38.3 de |
| ICGV 86158 | 35.1 cde | 83.3 a |
| ICGV 93291 | 30.1 de | 47.9 cde |
| ICGV 95322 | 25.4 e | 38.3 de |
| ICGV 86590 | 46.8 abc | 65.0 a-d |
| J 11 | 32.8 de | 71.7 a-d |
| ICGV 93280 | 31.6 de | 50.0 b-e |
| GH 51 | 34.3 de | 50.0 b-e |
| ICGV 95494 | 34.6 cde | 61.7 a-d |
| ICGV 99029 | 28.7 de | 42.5 cde |
| IC 48 | 36.1 cde | 72.7 abc |
| ICGV 91278 | 29.8 de | 43.8 cde |
| ICGV 91284 | 33.3 de | 66.7 a-d |
| ICGV 89104 | 30.2 de | 61.7 a-d |
| Anoa cultivar | 34.3 de | 43.3 cde |
| Bima cultivar | 32.1 de | 45.8 cde |
| Bison cultivar | 25.1 e | 25.0 e |
| Jerapah cultivar | 32.3 de | 48.3 b-e |
| Kelinci cultivar | 40.3 bcd | 63.3 a-d |
| Komodo cultivar | 32.9 de | 40.0 cde |
| Kancil cultivar | 40.9 bcd | 43.3 cde |
| Panter cultivar | 39.3 cd | 68.3 a-d |
| Singa cultivar | 56.1 a | 91.7 a |
| Turangga cultivar | 51.1 ab | 81.7 ab |
| Zebra cultivar | 36.3 cde | 60.0 a-d |
| DMRT 5% | 10.6 | 27.9 |

Note: Numbers in the same column followed by the same letter indicated not significantly different based on Duncan test at 5%

**Table 3.** The scores of leaf spot and rust diseases in 25 genotypes. Banjarnegara, wet-early dry season (February-May)

| Genotype | Leaf spot score*) | Rust score*) | Genotype | Leaf Spot score[1)] | Rust score[1)] |
|---|---|---|---|---|---|
| ICGV 86158 | 7.3 | 6.3 | Lamongan | 8.3 | 6.7 |
| ICGV 93291 | 7.0 | 5.7 | Anoa | 8.0 | 7.7 |
| ICGV 95322 | 6.7 | 5.3 | Bima | 7.0 | 6.0 |
| ICGV 86590 | 6.7 | 5.7 | Bison | 7.7 | 7.0 |
| J 11 | 7.7 | 6.3 | Jerapah | 8.0 | 7.3 |
| ICGV 93280 | 7.7 | 6.3 | Kelinci | 6.7 | 5.3 |
| GH 51 | 8.0 | 7.0 | Komodo | 8.0 | 7.3 |
| ICGV 95494 | 8.0 | 6.7 | Kancil | 8.0 | 6.3 |
| ICGV 99029 | 7.0 | 6.7 | Panter | 7.0 | 5.3 |
| IC 48 | 7.3 | 6.3 | Singa | 7.0 | 5.0 |
| ICGV 91278 | 7.7 | 6.3 | Turangga | 7.0 | 5.0 |
| ICGV 91284 | 7.0 | 6.3 | Zebra | 6.7 | 5.0 |
| ICGV 89104 | 7.7 | 6.7 | | | |

Note: *) Scored on a modified 1-9 scale where 1 = no disease and 9 = plants severely affected (scoring system followed Subrahmanyam et al. 1995). 1 = highly resistant, 2-3 = resistant, 4-5 = moderately resistant, 6-7 = susceptible, and 8-9 = highly susceptible (Subrahmanyam et al. 1995).

**Plant population**

The number of established plants of all genotypes at 14 DAS was high, i.e. >90% except those of Kelinci, Komodo, Bima, Bison varieties, ICGV 93291, ICGV 95322, ICGV 91278, J 11, ICGV 93291 genotypes (Tabel 6). Lower crop establishment of those nine genotypes was closely related to germination failure rather than plant wilting caused by *R. solanacearum* as the wilt symptom by this bacterial infection can be observed at least 3 weeks after sowing and the peak of occurrence will appear in 40-50 DAS (Wang et al. 2009). The level of infection was high as shown by high number of wilted plants at around harvesting time.

When looking at the number of wilted plants, ICRISAT genotypes had higher number of wilted plants compared to those of Indonesia cultivars (Table 6). All ICRICAT genotypes were heavily infected as figured out by >35% of wilt incidence and therefore classified as susceptible to bacterial wilt according to Machmud and Rais (1994) classification. These genotypes were maintained at ICRISAT Pathancheru, Andhra Pradesh, India where this country does not a geographical site for *R. solanacearum* infestation. Conversely, that bacteria is the important yield constraint in China, Indonesia and Vietnam, certain part of Malaysia and Uganda. Recently, bacterial wilt is observed in the Philippines, Thailand, Sri Lanka, Papua New Guinea, and India (Mehan et al. 1994).

Only two Indonesia cultivars (i.e. Singa and Turangga cultivars) showed moderately susceptible while the rest of Indonesia varieties, including Kelinci variety, were in susceptible category (Table 6). Previous study conducted by Saleh and Nugrahaeni (1996) in different site during dry season cropping, Kelinci cultivar had 28.3% of wilt

**Table 4.** Generative growth of 25 genotypes of groundnut grown at dryland. Banjarnegara, wet-early dry season (February-May)

| Genotype | No. of filled pods/plant | No. of empty pods/plant | No. of filled/ total pods (%) | Seed weight (g/plant) | Shelling out turn (%) | Dry pod yield (g/plant) |
|---|---|---|---|---|---|---|
| Lamongan | 24.3 a-d | 7.5 a-f | 76.4 | 13.2 a | 38.6 | 21.5 a |
| ICGV 86158 | 30.9 a | 9.9 a-e | 75.7 | 19.0 a | 35.6 | 29.5 a |
| ICGV 93291 | 22.8 a-d | 6.8 b-f | 77.5 | 9.4 a | 40.1 | 15.7 a |
| ICGV 95322 | 14.7 d | 5.3 def | 73.5 | 6.9 a | 32.1 | 11.9 a |
| ICGV 86590 | 19.8 bcd | 10.5 a-d | 65.3 | 10.5 a | 55.3 | 23.5 a |
| J 11 | 25.9 a-d | 10.7 abc | 70.7 | 16.8 a | 40.6 | 28.3 a |
| ICGV 93280 | 24.6 a-d | 6.5 b-f | 79.1 | 11.6 a | 49.6 | 23.0 a |
| GH 51 | 26.7 abc | 9.7 a-f | 75.4 | 15.7 a | 40.8 | 26.5 a |
| ICGV 95494 | 22.8 a-d | 9.3 a-f | 71.0 | 14.6 a | 43.4 | 25.8 a |
| ICGV 99029 | 17.7 bcd | 6.5 b-f | 73.1 | 9.6 a | 66.9 | 29.0 a |
| IC 48 | 16.1 cd | 6.5 b-f | 71.2 | 11.8 a | 42.2 | 20.4 a |
| ICGV 91278 | 16.2 cd | 5.5 c-f | 74.6 | 10.8 a | 42.6 | 18.8 a |
| ICGV 91284 | 27.7 ab | 7.8 a-f | 78.0 | 16.6 a | 40.1 | 27.7 a |
| ICGV 89104 | 27.6 ab | 11.1 ab | 71.3 | 16.7 a | 26.8 | 22.8 a |
| Anoa | 24.4 a-d | 5.1 ef | 82.4 | 13.4 a | 32.0 | 19.7 a |
| Bima | 19.6 bcd | 7.7 a-f | 71.8 | 11.7 a | 53.2 | 25.0 a |
| Bison | 16.3 cd | 6.3 b-f | 72.1 | 10.3 a | 48.0 | 19.8 a |
| Jerapah | 25.7 a-d | 6.1 b-f | 80.8 | 15.4 a | 35.1 | 23.7 a |
| Kelinci | 18.3 bcd | 12.2 a | 60.0 | 13.8 a | 38.2 | 22.3 a |
| Komodo | 22.1 a-d | 4.6 f | 82.7 | 12.4 a | 37.7 | 19.9 a |
| Kancil | 23.1 a-d | 7.2 a-f | 76.2 | 14.5 a | 39.1 | 23.8 a |
| Panter | 19.1 bcd | 8.6 a-f | 68.9 | 15.8 a | 43.8 | 28.1 a |
| Singa | 19.7 bcd | 6.6 b-f | 74.9 | 13.9 a | 42.3 | 24.1 a |
| Turangga | 18.8 bcd | 7.5 a-f | 71.5 | 13.4 a | 42.0 | 23.1 a |
| Zebra | 17.7 bcd | 10.0 a-e | 63.8 | 14.6 a | 39.5 | 24.1 a |
| DMRT 5% | 9.2 | 4.3 | -- | ns | -- | ns |

Note: Numbers in the same column followed by the same letter indicated not significantly different based on Duncan test at 5%

**Table 5.** The correlation coefficients among vegetative and generative parameters obtained from 25 genotypes. Banjarnegara, wet-early dry season (February-May)

| | Plant height | Fresh haulm weight | No. of filled pods | No. of empty pods | Shelling outturn | Seed yield | Leaf Spot | Rust | Pod yield/ plant |
|---|---|---|---|---|---|---|---|---|---|
| Plant height | -- | 0.542 *** | 0.101 | 0.048 | 0 | 0.207 | -0.201 | -0.384 *** | 0.235 ** |
| Fresh haulm weight | | -- | 0.305 *** | 0.449 *** | 0.145 | 0.442 *** | -0.296 ** | -0.342 ** | 0.378 *** |
| No of filled pods | | | -- | 0.273 ** | 0.298 *** | 0.601 *** | 0.431 *** | 0.371 *** | 0.488 *** |
| No of empty pods | | | | -- | 0.121 | 0.295 *** | -0.181 | -0.175 | 0.233 ** |
| Shelling outturn | | | | | -- | 0.642 *** | 0.312 *** | 0.137 | -0.083 |
| Seed yield | | | | | | -- | 0.292 ** | 0.121 | 0.688 *** |
| Leaf spot | | | | | | | -- | 0.682 *** | 0.122 |
| Rust | | | | | | | | -- | 0.067 |
| Pod yield/plant | | | | | | | | | -- |

**Table 6.** Number of emerged plants, number of wilted plants and the resistance status to bacterial wilt of 25 peanut genotypes. Banjarnegara, wet-early dry season (Februay-May)

| Genotype | Number of emerged plants at 14 DAS (%) | Bacterial wilt incidence[1] (%) | Disease reaction [2] |
|---|---|---|---|
| Lamongan | 91.5 a-e | 80.2 cd | S |
| ICGV 86158 | 92.0 a-d | 90.5 abc | S |
| ICGV 93291 | 82.8 c-g | 98.0 ab | S |
| ICGV 95322 | 84.6 b-g | 97.6 ab | S |
| ICGV 86590 | 90.8 a-f | 51.7 e | S |
| J 11 | 82.3 d-g | 95.9 a | S |
| ICGV 93280 | 88.3 a-g | 88.9 a-d | S |
| GH 51 | 92.1 a-d | 78.5 d | S |
| ICGV 95494 | 93.1 abc | 94.6 ab | S |
| ICGV 99029 | 90.0 a-f | 95.1 ab | S |
| IC 48 | 94.4 ab | 97.8 ab | S |
| ICGV 91278 | 80.5 fg | 96.3 ab | S |
| ICGV 91284 | 95.1 ab | 95.5 ab | S |
| ICGV 89104 | 95.1 ab | 96.5 ab | S |
| Anoa | 93.1 abc | 41.1 efg | S |
| Bima | 84.6 b-g | 94.0 ab | S |
| Bison | 80.8 ef | 87.8 a-d | S |
| Jerapah | 93.6 ab | 44.8 ef | S |
| Kelinci | 78.0 g | 46.3 ef | S |
| Komodo | 87.4 a-g | 86.6 bcd | S |
| Kancil | 95.9 a | 39.6 fg | S |
| Panter | 91.0 a-f | 52.1 e | S |
| Singa | 90.5 a-f | 32.6 g | MS |
| Turangga | 89.3 a-f | 33.9 g | MS |
| Zebra | 91.8 a-d | 45.1 ef | S |

Note: Values in the same column followed by the same letters did not significantly different based on Duncan test at P≤0.05. [1]. Bacterial wilt incidence (%) was calculated from the number of wilted plants over the number of plants at 12 DAS. [2]. Resistant (R): 0-15% wilt incidence; Moderately Resistant (MR): 16-25% wilt incidence; Moderately Susceptible (MS): 26-35% wilt incidence; Susceptible (S):>35% wilt incidence (Machmud and Rais, 1994).

**Tabel 7.** Number of harvested plants and pod yield per plant. Banjarnegara, wet-early dry season (February-May)

| Genotype | Dry pod yield (g/plant) | No. of harvested plants (%) | Production ($t\ ha^{-1}$ of dry pods) | The predicted production ($t\ ha^{-1}$ of dry pods) *) | Yield reduction (%) |
|---|---|---|---|---|---|
| Lamongan | 21.5 | 19.8 | 0.287 | 1.449 | 80.2 |
| ICGV 86158 | 29.5 | 9.5 | | | |
| ICGV 93291 | 15.7 | 2.0 | | | |
| ICGV 95322 | 11.9 | 2.4 | | | |
| ICGV 86590 | 23.5 | 48.3 | 1.125 | 2.329 | 51.7 |
| J 11 | 28.3 | 4.1 | | | |
| ICGV 93280 | 23.0 | 11.1 | | | |
| GH 51 | 26.5 | 21.5 | 0.559 | 2.599 | 78.5 |
| ICGV 95494 | 25.8 | 5.4 | | | |
| ICGV 99029 | 29.0 | 4.9 | | | |
| IC 48 | 20.4 | 2.2 | | | |
| ICGV 91278 | 18.8 | 3.7 | | | |
| ICGV 91284 | 27.7 | 4.5 | | | |
| ICGV 89104 | 22.8 | 3.5 | | | |
| Anoa | 19.7 | 58.9 | 1.180 | 2.003 | 41.1 |
| Bima | 25.0 | 6.0 | | | |
| Bison | 19.8 | 12.2 | | | |
| Jerapah | 23.7 | 55.2 | 1.055 | 1.911 | 44.8 |
| Kelinci | 22.3 | 53.7 | 0.753 | 1.402 | 46.3 |
| Komodo | 19.9 | 13.4 | | | |
| Kancil | 23.8 | 60.4 | 1.304 | 2.158 | 39.6 |
| Panter | 28.1 | 47.9 | 0.970 | 2.025 | 52.1 |
| Singa | 24.1 | 67.4 | 0.978 | 1.451 | 32.6 |
| Turangga | 23.1 | 66.1 | 1.025 | 1.550 | 33.9 |
| Zebra | 24.1 | 54.9 | 0.567 | 1.032 | 45.1 |
| Average | 22.7 | 46.8 | | | |

Note: *) predicted under full population (100% harvested plants)

incidence and therefore categorized as moderately susceptible. This different reaction probably due to different pathotypes between the sites as reported by Wang et al. (2009).

The number of harvested plants varied from 2.0% to 67.4%. This figure explained that plant population at harvesting time was very low. Due to this situation, the pod yield did not available for all 25 genotypes, but only for genotypes with higher number of survival plants (Table 7). In other words, pod yield at harvesting time was available only to some genotypes that had higher plant populations. These survival plants were the plants that showed some resistance to bacterial wilt incidence. The data showed that Kancil cultivar resulted in highest pod production, while ICGV 86590, Anoa, and Jerapah cultivars came afterward with lower yields. These higher pod productions seem to correlate to higher number of harvested plants and higher plant productivity. On the other hands, the yield reduction positively correlated to high reduction in plant population (Table 7).

### *Aspergillus flavus* infection

The observation of *A. flavus* infection on seeds was undertaken only to the genotypes with high number of plant population at harvesting time, as those genotypes provided enough amounts of seeds. The experiment shows that Local Lamongan, ICGV 86590, GH 51, Jerapah, Kelinci, Turangga, Anoa, and Zebra were highly resistant with seeds infected by *A. flavus* lower than 15%. Mean while Kancil, Panter, and Singa cultivars were grouped as moderately resistant to *A. flavus* infection (Table 8).

ICISAT lines which were resistant to in-vitro seed colonization (ICGV's 93280, 95494, J11) and tolerant to pre-harvest seed infection by *A. flavus* (ICGV 89104) were devastated by *R. solanacearum* bacteria. Only one line, ICGV 86590, was survived.

Singa cultivar grew vigorously as shown by the tallest plant (56.1 cm) with the heaviest fresh fodder (91.7 g). Conversely, Bison had the lowest values both its height and weight, with 25.1 cm height and 26.7 g weight only. One of the ultimate reasons for this difference was the type of growth where Singa variety is Valencia type and Bison variety is Spanish type. Generally, Valencia type grows taller with more leaves and stronger stems compare to that of Spanish type. Highest green fodder yield per plant and

**Table 8.** Number of *A. flavus* incidence on some peanut genotypes. Banjarnegara, wet-early dry season (February-May)

| Genotype | Seed infected by *A. flavus* (%) | Rust score*) | Genotype | Seed infected by *A. flavus* (%) | Rust score*) |
|---|---|---|---|---|---|
| ICGV 86158 | - | - | Lamongan | 0 | HR |
| ICGV 93291 | - | - | Anoa | 11.0 | HR |
| ICGV 95322 | - | - | Bima | - | - |
| ICGV 86590 | 3.0 | HR | Bison | - | - |
| J 11 | - | - | Jerapah | 4.0 | HR |
| ICGV 93280 | - | - | Kelinci | 9.7 | HR |
| GH 51 | 9.3 | HR | Komodo | - | - |
| ICGV 95494 | - | - | Kancil | 19.7 | MR |
| ICGV 99029 | - | - | Panter | 19.3 | MR |
| IC 48 | - | - | Singa | 27.3 | MR |
| ICGV 91278 | - | - | Turangga | 7.0 | HR |
| ICGV 91284 | - | - | Zebra | 4.5 | HR |
| ICGV 89104 | - | - | | | |

Note: *) Highly resistant (HR): <15% seed infection; moderately resistant (MR): 15-30% infection; moderately susceptible (MS): 30-50%; highly susceptible (HS): >50% (Siulin et al. 1996).

its tallest plant of Singa cultivar was supported by Özyiğit and Bilgen (2013) who reported that cultivar with highest green fodder yield had tallest plant.

It is summarized that more genotypes had shorter and lighter than its average values. Based on the data of the experiment, it should be mentioned that plant height tent to positively correlate to fresh haulm weight (r: 0.542).

The dominance of leaf spot in wet season crops was supported by earlier study in Indonesia by Saleh and Nugrahaeni (1996) as well as the screening for leaf spot resistant lines conducted at ICRISAT (Subrahmanyam et al. 1995), and recent study in Nepal (Thakur et al. 2013). Meanwhile, Saleh and Trustinah (1996) reported that rust incidence was more dominant during dry season planting. The development of leaf spot disease is contributed by rainfall or irrigation, and high humidity during the growing season (Kumar et al. 2013). Even in drier areas (with average minimum and maximum air temperatures of 23 and 31$^{o}$C) like in Ghana, groundnut crops also suffered from foliar diseases as the presence of rainfall 42-305 mm/month in 3-17 rain days/month during 6 months of cropping season.

The scores of leaf spot and rust diseases in groundnut with Valencia type (such as Kelinci, Panter, Singa, Turangga, Zebra, and ICGV 86590) was lower compared to those of cultivars with Spanish type. One of the reasons was Valencia type has thicker leaflet. Early study at ICRISAT reported that almost all resistant lines to both diseases were the fastigiata or Valencia type (Subrahmanyam et al. 1995).

Leaf spot disease will end up with defoliation, and rust disease causes necrotic. These two conditions reduce fresh weight of leaves. Therefore, the incidence of leaf spot or rust individually affects haulm weight; the similar result was obtained by Sunkad and Kulkarni (2006). In this experiment, there was significantly negative correlation between fresh haulm weight and leaf spot. Thakur et al. (2013) reported that genotypes that produced highest haulm weight had low leaf spot incidence. In regard to rust disease, the significant negative correlation to plant height and fresh haulm weight existed (Table 5). Instead of reducing weight, leaf spot infection reduces the quality (crude fiber, crude protein, fat and dry matter content of haulm) of groundnut haulm (Bdliya 2007).

Leaf spot disease reduced both quantity and quality of haulm, while rust disease resulted in short plant with less fresh haulm weight of groundnut plants. Therefore, applying fungicide to control the disease or growing a resistant cultivar is suggested to ensure good quality and quantity of haulm. Apart from haulm weight reduction, rust incidence also negatively correlated to plant height. It means that severe rust incidence was followed by short plants.

In conclusion, there were no introduced genotypes from ICRISAT which had the resistant response to the wilt infection better than that of Indonesian cultivars. All the genotypes from ICRISAT were susceptible to *R. solanacearum* infection when cultivated in Indonesia. Valencia type of growth of the Indonesian cultivars relatively had better resistance to bacterial infection. These cultivars also resistant to rust and *A. flavus* infection into their seeds. Three genotypes, i.e. Kancil, Anoa cultivars and ICGV 86590 produced higher pod yield among those genotypes which relatively resistant to bacterial wilt incidence, therefore, could be considered as one of the parents in groundnut breeding program.

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