The response of several groundnut cultivars on fertilization in drylands with the dry climate

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Abstract. The existing technology for growing groundnuts in drylands with the dry climate in East Sumba District of East Nusa Tenggara Province is very simple/ordinary, and the introduction of superior groundnut cultivar and improved technology are predicted will increase its productivity. The experiment was undertaken to find out the performance of improved technology and superior cultivars on increasing pod yield productivity. The experiment was done at Laipori Village, Pandawai Subdistrict, East Sumba District from February-May 2018. The experiment applied a randomized block design two factorial with three replicates. The treatments consisted of two factors. Factor one was five groundnut genotypes (five superior: Kancil, Hypoma 3, Hypoma 1, Hypoma 2, and Kelinci and one local Sandel cultivar), factor 2 was two types and dosages of fertilization (low: 50 kg Phonska/ha, high: 100 kg Phonska/ha+50 kg SP36+500 kg FYM/ha). The results indicated that initial soil fertility status was high pH (>7.0), low total N, moderate available P, high K, Ca, Mg concentration. The improved technology that has been tested consisted of superior cultivar of Kancil, and the application of 50 kg Phonska/ha. Kancil cultivar was able to increase pod yield by 26% higher than that of Local Sandel cultivar.

1. Introduction

One of the Indonesia agriculture development targets is an effort to increase food diversification which emphasizing on diversifying the sources of carbohydrate and protein other than rice. Groundnuts are considered to be very suitable to support the food diversification program base on its nutrient contents. The protein content of groundnut, which is 25.8 g/100 g on average, is the highest among grains and legumes while the carbohydrate content is 16.13 g/100 g [1]. The total areas of groundnut crops in Indonesia are 454,063 hectares (ha) with yield productivity is 1.29 t/ha at the research-level [3]. Therefore, there is a window of opportunity to increase national productivity. In Indonesia, more than 50% of planting areas for groundnuts are located in Java Island [4] with 139,544; 81,395; and 43,761 ha in East, Central, and West Java, respectively, and 70,888 ha in Jogjakarta. Despite Java Island dominates the planting areas for groundnut, the planting areas have been reducing since the last five years. Therefore, the Government needs to extend the planting areas to the lands that have not been intensively utilized for agriculture i.e. suboptimum soils. These suboptimum soils will be the incoming agriculture lands. In Indonesia, there is a large number of suboptimum soils that can be used for agriculture such as 0.48 million ha of saline soils [5], 13.3 million ha drylands with the dry climate where 3 and 1.5 million ha are located in East and West Nusa Tenggara, respectively [6].
The ultimate problem in drylands with dry climate is water availability as a result of low precipitation where there is <2,000 mm rainfall/year in 3 months period only. This condition gives a very short of the sowing period. The rains generally come irregularly or erratically and therefore it is difficult to set the precise cropping pattern [6-7]. Widiyono [8] reported the potency of drylands with the dry climate at East Sumba for groundnut cultivation in dry season instead of wet season cultivation. In dry season planting, water requirements would be fulfilled from the river where the water always available throughout the year. He reported that the application of organic manure from cattle was successfully increased the vegetative growth of 6 groundnut cultivars. The dry condition with low rainfall gives less soil nutrient leaching and results in high alkaline content and soil fertility [9]. This statement supports the fertility condition of drylands with the dry climate in the Sumba Timur District of East Nusa Tenggara as reported by [10]. In this district, the growth of groundnut plants is influenced by altitude. This is based on the reason that altitude influences soil fertility. At 0-200 m above sea level (asl), the pH, total nitrogen (N), and Fe content in the soil are becoming the constraint of groundnut growth. Whilst at 200-700 m asl, pH of the soil and all nutrients are optimally available for groundnut growth. At an altitude higher than 700 m asl, the low concentration of N total and P available, and high C:N ratio is becoming constraints for groundnut growth. These different nutrient status are very crucial in composing the cultivation technology for groundnut in order to create the optimum environments for groundnut plants in achieving high pod yield. The existing (local) technology for growing groundnut in drylands with a dry climate and less than 3 months period of rains at Sumba Timur District is available. This technology is very ordinary and even simple i.e. no soil tillage, no fertilization, random plant spacing, and local cultivar. Due to this condition, there is a need to improve the cultivation technology of groundnut as well as introduce superior cultivar to increase the productivity and production of groundnuts from drylands with a dry climate.

2. Methods

The research was conducted at Sumba Timur District, East Nusa Tenggara Province from February-May 2018. The research was arranged in a randomized block design and three replicates. There were two factors studied: the first factor was six cultivars (Lokal Sandel, Kancil, Hypoma 3, Hypoma 1, Hypoma 2, and Kelinci), and the second factor was 2 levels of type and dose of fertilizers (Table 1). The combination of both treatments resulted in 12 combinations treatment, and each combination was planted in a 4 m x 4 m plot size. Soil tillage was undertaken into a 20 cm depth, the crops were intensively maintained so that they were free from weed infestation especially during the first 50 days after sowing (DAS), pest and disease were intensively controlled. Fertilizers were applied close to the seed holes along the rows at planting time.

The observation was on chemical characters of soil (pH, C-organic, N, P, K, Ca, Mg, CEC, and Fe) before sowing time, and pH, N, P and K of soils at harvesting time, plant height at 45 DAS and at harvesting time, haulm weight at harvesting time, number of filled and empty pods/plant, fresh and dry pod weight/plant, and fresh and dry pods yields/plot. An analysis of variance was applied to all variables and when there was a significant difference, a Duncan test at a 5% level of significance was applied. These statistical analysis tools were available on the Mstat C program.

| Table 1. Type and dose of fertilizer treatments for groundnuts, Sumba Timur, 2018. |
|---------------------------------------------|---|---|
| Type of fertilizers                      | Treatment | P1 | P2 |
| Phonska (composite NPKS)                  | kg/ha     | 50 | 100|
| SP36 (phosphate)                         | kg/ha     | -  | 50 |
| Farm yard manure                         | kg/ha     | -  | 500|
3. Results and discussion

3.1. Chemical characters of soils prior experiment

Chemical analysis of soils before initiating the experiment showed that soil pH was 8.6, and therefore categorized as alkaline soils. This high soil pH very influences the availability of nutrients especially for Fe that was undetected in the analysis. This means that Fe was unavailable in high soil pH. The unavailability of Fe to groundnut plants resulted in chlorotic symptoms as the leaves turn to yellow. The chlorotic symptom is very common for groundnut crops in Sumba Timur.

The analysis also showed that total N content was low, P was moderately available, and the concentration of K, Ca, and Mg was high (Table 2). This high Ca and Mg concentrations were potentially disturbed the nutrients balance in the soil. Groundnuts will have the best pod production at soil pH 6.0 – 6.5, and in the range 4.5-7.0 soil pH groundnuts are able to grow. Once the soil pH is >7.0, low Fe content in the soil will potentially prompt the plants to suffer from chlorotic. The critical N and P content is 0.1% and 7 ppm P₂O₅ (Bray 1 method), respectively. The shortage of N gives a consequence on low chlorophyll content and results in chlorotic leaves. The symptom of N shortage of plants occurs when the crops are grown in soil with the poor drainage system. Under this anaerobic condition, N fixing bacteria fail to grow and N absorption activity is inhibited.

Table 2. The chemical analysis of soil prior to sowing Pandawai Subdistrict, Sumba Timur District 2018.

| Location     | pH | N  | C-org | P   | K   | Ca | Mg | CEC | Fe ppm |
|--------------|----|----|-------|-----|-----|----|----|-----|--------|
| Pandawai     | 8.6| 0.06| 2.45  | 14.18| 0.77| 74.4| 4.22| 66.4 | Ud*)   |
|              |    |    |       |     |     |     |     |      |        |
|              |    |    |       |     |     |     |     |      | (*) ud: undetected (very low content) |

3.2. Yield and yield components of groundnut cultivars

Statistical analysis informed that there was no interactive effect of cultivar and fertilization on pod yield and all yield components. Fertilization treatment also did not give any significant effect on those variables (Table 3). Cultivars, however, gave a significant effect on pod yield and its yield components.

Table 3. Analysis of variance of pod yield and yield components of cultivar and fertilization treatments. Pandawai, Sumba Timur, 2018.

| Anova     | Plant height at 45 DAS | Plant height at the harvest-ing time | No of branches per plant | No of filled pods per plant | Haulm weight/plot | Pod yield/ha |
|-----------|------------------------|-------------------------------------|--------------------------|-----------------------------|--------------------|--------------|
| Cultivar (C) | s                      | s                                   | s                        | s                           | s                  | s            |
| Fertilization (F) | ns                    | ns                                  | ns                       | ns                          | ns                 | ns           |
| C x F     | ns                     | ns                                  | ns                       | ns                          | ns                 | ns           |
| KK (%)    | 9.55                   | 8.15                                | 9.43                     | 14.58                       | 19.28              | 15.63        |

Notes: s: 5% significance, ns: not significant
Phonska/ha) application together with 50 kg SP36/ha + 500 kg FYM/ha did not increase plant height at harvesting time as those that received 50 kg Phonska/ha only (Table 4).

Fertilization did not give any significant effect on the number of branches, but the cultivar did. The highest number of branches was for Kancil and Kelinci cultivars. Despite these two cultivars grew the shortest, they produced the highest number of branches. This phenomenon showed that these two cultivars had short internodes. Similar to plant height, either high or lower fertilizer dose gave the same number of branches (Table 4).

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A similar trend was also presence for haulm weight at harvesting time i.e. fertilization treatment did not influence the haulm weight as it was merely affected by cultivar. Kelinci cultivar produced the highest haulm weight and significantly higher than that produced by Hypoma 2 cultivar. High production of fresh haulm is very important in drylands with dry climate as the haulm most probable as a feed source. Sumba Timur is one district that has a high amount of cattle as almost every farmer raises cattle, and groundnut haulms are very suitable fodder to both cows and horses.

Pod yield per hectare followed the previous variables as this parameter was only governed by cultivar. The increasing amount and type of fertilizers were not followed by increasing pods yield. Again, under the agroecology of fertile drylands with the dry climate of Sumba Timur, the application of 50 kg Phonska/ha was enough for the crops to increase the amount of pod yield. The highest pod yield was obtained by Kancil cultivar and followed by Hypoma 3, Lokal Sandel, Hypoma 2, Hypoma 1, and Kelinci, successively.

### Table 4. Yield and yield components of several groundnut cultivars and fertilization levels. Pandawai, Sumba Timur, 2018.

| Treatment | Plant height at 45 DAS (cm) | Plant height at harvesting time (cm) | No of branches per plant | No of filled pods per plant | Haulm weight (kg/plot) | Pod yield (kg/ha) |
|-----------|-----------------------------|--------------------------------------|--------------------------|----------------------------|------------------------|------------------|
| **Cultivar** |                             |                                      |                          |                            |                        |                  |
| Local Sandel | 27.8 ab                     | 33.8 ab                              | 5.0 c                    | 10.3 c                     | 11.7 ab                | 2,521 ab         |
| Kancil     | 27.3 ab                     | 32.5 b                               | 7.2 a                    | 14.8 a                     | 12.3 ab                | 3,177 a          |
| Hypoma 3   | 30.3 ab                     | 36.2 ab                              | 5.9 bc                   | 14.8 a                     | 13.9 a                | 3,135 a          |
| Hypoma 1   | 31.5 a                      | 38.7 a                               | 4.9 c                    | 11.6 abc                   | 12.0 ab               | 2,431 ab         |
| Hypoma 2   | 30.7 ab                     | 38.4 a                               | 4.1 d                    | 13.8 ab                    | 9.9 b                 | 2,458 ab         |
| Kelinci    | 24.9 b                      | 32.3 b                               | 6.4 ab                   | 10.9 bc                    | 14.3 a                | 2,146 b          |
| **Fertilization** |                         |                                      |                          |                            |                        |                  |
| P1         | 28.2                        | 34.6                                 | 5.5                      | 12.5                       | 12.4                   | 2,597            |
| P2         | 29.3                        | 35.9                                 | 5.7                      | 12.9                       | 12.3                   | 2,693            |

Notes: P1: 50 kg Phonska/ha; P2: 100 kg Phonska + 50 kg SP36 + 500 kg FYM/ha.
It can be summarized that cultivar gave a significant effect on yield and yield components. It means that significant yield differences among those six cultivars were the result of the differences in their yield components. Mahrous et. al [11] obtained a similar result on their work in two groundnut cultivars grown in sandy soils with low nutrient contents and neutral soil pH. Cultivar Kancil obtained the highest pod yield, and it was 26% higher than that obtained by Local Sandel cultivar. This indicated that Kancil cultivar is the potential to be developed in drylands with dry climate Sumba Timur to accompany the local Sandel cultivar that has been grown by farmers since a long time ago. The ultimate superiority of Kancil cultivar is high productivity and its tolerance to chlorotic symptoms as a result of Fe unavailability under high soil pH.

The result of the experiment also showed that plants that received 50 kg Phonska/ha had the same vegetative and generative growth as well as pod yield to those received 100 kg Phonska + 50 kg SP36 + 500 kg FYM/ha. It means that the application of 50 kg Phonska/ha has already enough for the plants to obtain their optimum pod yield. This result is in accordance with the results obtained in the previous experiment i.e. application of 50 kg Phonska/ha gave higher pod yield than the plants without any fertilizer as practiced by farmers using existing technology. One of the reasons farmers did not apply any fertilizer to that groundnut crops is because the soils are fertile. Wijanarko and Rahmianna [10, 12] reported that the fertility of Sumba Timur soils is high with high N, P, K, and organic matter contents. They also did a grouping of soil fertility based on altitude. At 0-200 m asl, the pH, N total, and Fe constrained the groundnut growth. The groundnut crops grew at soil pH 4.5 – 7.0, but the crops gave a good pod yield at soil pH 6.0 – 6.5. The experimental site is located in the range of 0-200 m asl with soil pH was 7.5. Under this high soil pH, P, K, Ca, Mg, and organic matter contents were high but Fe content was low i.e. 3.52 ppm that resulted in chlorotic of the plants. In enabling the vegetative and generative growths, all these nutrients should be readily available to plants. Phosphorus is needed for nodules formation. Lack of P retards N fixation. Phosphorus also plays a role in various chemical and molecular processes ultimately in building and utilizing energy in the plants, accelerates flowering and pod maturity [13]. Groundnuts need a high amount of potassium (K). This potassium plays as a catalyst agent in the metabolism process such as enzyme activation, reduce water transpiration through stomata regulation, increase ATP production, assimilate translocation, increase N absorption, and protein synthesis [14]. The requirement of groundnut plants for calcium is quite high during the pod filling period. This nutrient is directly absorbed by pods from the surrounding soils. The lack of calcium will result in small seeds, low oil content [15]. Calcium is required by the plants at the initiation of gynophores elongation, seed setting and pod maturity. Calcium also acts as a growth and development plant regulator [16]. High nutrient content within the soil during the experiment caused a high dosage of fertilization applied did not give any effect on pod yield. On the contrary, under low soil fertility with low Ca concentration, the application of NPK inorganic fertilizers combined with farmyard manure and gypsum as Ca (mainly) and S source increased pod and seed yield of groundnut. Gypsum had an important effect on the yield either on NPK inorganic fertilizer alone or when it was combined with farmyard manure [17]. It can be summarized that growing superior cultivar Kancil or Hypoma 3 with the application of 50 kg Phonska/ha had a good prospect to be disseminated in drylands with the dry climate in Sumba Timur.

3.3. Chemical characters of soil after the experiment

At the completion of the experiment, soil pH was >8 in all treatment plots (Tabel 5). These were as high as that at the initial of the experiment. The concentration of N was in the range 0.1-0.13% (Table 5), and N fertilization will give any response when N concentration in the soil is 0.06-0.1%. The concentration of P was high: 11.8-17.8 ppm P2O5 (Table 5) and the critical P content for groundnut is 8,7 ppm P2O5 [18]. Potassium concentration after the experiment was high and ranged from 0.33-0.40 cmol/kg while the critical amount of potassium for groundnut was 0,20-0,30 cmol/kg.

The good status of P available both before and after the experiment and high C organic content in the soils before the experiment might be the reason for the absence of fertilization treatments on groundnut yield and its yield components. On the contrary, the combination of P fertilizer and farmyard
manure was successfully increased pod yield of groundnut grown under low organic carbon and P available in soils [19]. Mbah and Akpan [20] highlight the application of the appropriate type of manure that basically depends on the amount of total nitrogen, phosphorus, pH, organic matter and organic carbon.

Table 5. The effect of fertilization of some groundnut cultivars on chemical characters after the completion of the experiment.

| Treatment     | pH  | N total (%) | P available (ppm P$_{2}$O$_{5}$) | K available (cmol/kg) |
|---------------|-----|-------------|---------------------------------|-----------------------|
| Cultivar      |     |             |                                 |                       |
| Lokal Sandel  | 8.1 | 0.10        | 13.5                            | 0.35                  |
| Kancil        | 8.1 | 0.11        | 14.4                            | 0.40                  |
| Hypoma 3      | 8.4 | 0.11        | 16.0                            | 0.36                  |
| Hypoma 1      | 8.3 | 0.11        | 17.8                            | 0.33                  |
| Hypoma 2      | 8.3 | 0.13        | 11.8                            | 0.36                  |
| Kelinci       | 8.1 | 0.10        | 13.7                            | 0.32                  |
| Fertilization |     |             |                                 |                       |
| P1            | 8.3 | 0.11        | 14.1                            | 0.35                  |
| P2            | 8.1 | 0.10        | 15.0                            | 0.35                  |

Notes: P1: 50 kg Phonska/ha; P2: 100 kg Phonska + 50 kg SP36 + 500 kg FYM/ha.

4. Conclusion
Chemical analysis of soils pointed out that the experimental site was categorized as alkaline soils because of high soil pH (>7). The N total concentration was low, available P was moderate, K, Ca, and Mg concentrations were high. The cultivation of technology for groundnuts that potential to be developed in drylands with dry climate was introducing superior cultivar Kancil applied by 50 kg/ha of Phonska.

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