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Minimum Fertilizer in Maize Varieties for Economically Disadvantaged Farmers in Suboptimal Land

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Abstract.

Farmers on suboptimal land are generally economically disadvantaged and need to be supported by low-cost technology. The study aimed to find out a low input technology package for maize cultivation on suboptimal land in Riau Province. The research was carried out on the tidal agroecosystem overflow type C, around the Mandau River on alluvial land, peat, and alluvial + peat mixture in Siak District. Time of study in March to December 2018. The materials used were hybrid maize varieties such as Nasa 29, Bima Uri 19, and composite maize Bisma and Sukmaraga, Urea, TSP, KCl, farm yard manure, dolomite, locality liquid organic fertilizer (LLOF), grilled ash, biological fertilizers, decomposers, pesticides, herbicides. There are 4 fertilization packages, i.e.: A (high dosage), B (high dosage + LLOF + Grilled ash), C (50% dosage + LLOF + grilled ash), D (low dosage). Experiments were designed using randomized complete block design and repeated three times. To find out whether farming is profitable or not economically, it is analyzed by using Benefit Cost Ratio. The results showed that Nasa 29 and Sukmaraga varieties produced the best average growth and yield for all soil types and fertilizer doses of 4.0 t ha^{-1} and 3.9 t ha^{-1} dry seeds, respectively. NASA 29 can produce 6.2 t ha^{-1} dry seeds in a mixture of peat + alluvial soil even though the dose of chemical fertilizer is reduced by 50%. Reducing the dose of chemical fertilizer can be done to improve the ability of farmers to buy fertilizer depending on the type of soil and the availability of LLOF and grilled ash. Mixture of peat and alluvial is good soil for maize growth if combined with fertilizer package B. Decrease in chemical fertilizer 50% (package C) causes yields to fall to 6.23 t ha^{-1} and farmers get a profit of Rp 12,418,000 per planting season with B/C 1.9.

Keywords: Maize, low cost, suboptimal, alluvial, peat, liquid organic fertilizer

1. Introduction

One of the targets of extensification for food crops in Indonesia is suboptimal land, such as peat and alluvial in tidal areas. Indonesia has 11 million ha of tidal swamps and 14.9 million ha of peatlands (Mulyani and Sarwani, 2013). According to Notohadiprawiro (1971), alluvial associated with organic land is 44.6 million ha or 23.5% of the land area of Indonesia. Suboptimal soils are distributed along river basins (Sirappa and Titahena, 2014), which in Riau Province is dominated by peat and alluvial soils. These lands are widely used for oil palm or rubber plantations and only a small portion is used for food crop agriculture due to physical, biophysical and chemical inhibiting factors.

Problems in peat soils are related to acid sulphate soils, depths of pyrite layers, tidal dynamics, depth of ground water surface, and soil acidity (Könönen et al., 2015;

Salimin et al., 2010), nutrient Ca, Mg, K and Na, P_2O_5 and K_2O deficiency. The characteristics of peat soils in Riau are very acid soil reaction with pH (H_2O) 3.3 - 3.9, very high organic carbon content, very high carbon stocks, hemic to sapric maturity in the top layer, low bulk density 0.16 - 0.24 g cm^{-3}, content of micro elements of Cu, Mn and Zn were generally moderate to high, Fe content was very high, and high content of exchangeable Al (Hikmatullah and Sukarman, 2014). Based on the criteria of land suitability for agricultural commodities (Ritung et al. 2011), the peat soils of Riau with hemic to sapric maturity, thickness of more than 3 m and clay substratum were classified into marginally suitable for perennial crops (rice, maize , legumes), but moderately suitable for annual crops, such as palm oil and coconut.

The peat soils need inputs such as fertilizers and ameliorants to improve and maintain soil fertility. Some ameliorants such as pugam, manure, inorganic fertilizers, dolomite, and zeolite can be used for peat soils (Hikmatullah and Sukarman, 2014). Subiksa (2013), suggested to use pugam to improve peat soils fertility as ameliorant and fertilizer and decreasing greenhouse gas. Some ameliorant has been applied in order of importance in the fields, namely lime/dolomite, mineral soils, organic fertilizers, combustion ash, and volcanic ash.

Alluvial soils around the Siak River and Mandau River in Riau Province are contains very much iron so that rice plants often experience iron poisoning and cause crop failure. A very high clay content causes the soil to become very hard in the dry season. According to Kasno et al. (2003), alluvial deposits are generally fine-textured, with clay fraction content > 50%. The content of organic matter in alluvial soil of rice fields are varies in the upper layer, some are relatively low (<2%). Meanwhile according to Obia et al. (2018), heavy clay soils are globally widespread but their poor drainage and poor aeration limits their use for agriculture.

Technology suboptimal land management can be done through amelioration, balanced fertilization, tillage and water management (Adnyana et al., 2005), addition of organic materials as fertilizer (Kaderi, 2004; Tisdale et al. 1985), organic fertilizers as much as 2 Mg ha^{-1} in combination with inorganic fertilizers to rice cultivation in the integrated crop management (Pirngadi and Makarim, 2006), organic materials as much as 5 Mg ha^{-1} and 100 kg KCl ha^{-1} were increasing grain yield (Pirngadi and Pane, 2004). Indiscriminate use of hazardous synthetic fertilizers and pesticides caused environmental pollution and deteriorated soil health (Elkoca and others 2010). Proper nutrient management is essential to maximize maize production and sustain agricultural production while minimizing negative impacts on the soil fertility (Mahamood, et al. 2016).

Farmers on suboptimal lands are generally economically disadvantaged farmers. Improvement of soil fertility with the addition of organic material, lime, and high-dose chemical fertilizers is not able to be implemented. Therefore this suboptimal peat and alluvial land becomes unproductive agricultural land. In addition, land clearing using heavy equipment has damaged the soil layer by eroding thin peat that is above the alluvial substratum. Traditional tillage has also caused peat and alluvial to mix. Thus, land along the Siak River can be peat, alluvial, or a mixture of peat with alluvial. Rice and maize cultivation in these three types of soil is unsatisfactory because rice is iron poisoned and maize grows stunted. Farmers need low-cost technology to empower the potential of this vast land. This suboptimal soil can provide benefits with high-dose ameliorant and fertilizer applications. But Burke et al. (2016) conveyed that higher fertilization rates would be marginally profitable or unprofitable in many cases given commercial fertilizer and maize prices. Some efforts to neutralize soil acidity, especially in topsoils are categorized as relatively difficult, expensive and need a comprehensive approach (Armanto et al., 2016).

One way to help farmers is low input technology, increasing the efficiency of fertilizers provided and mining nutrient stocks in the soil and fixation N from the air with biological fertilizers. This method can be done several times the growing season until farmers are able to buy ameliorant and chemical fertilizer.

Low-input system characteristics depend on local conditions, especially on soil fertility and on potential yields. Low-input systems rely on a large variety of strategies to reduce synthetic inputs, especially on crop species diversification to reduce N fertilization (Colnenne-David and Doré, 2015), integrated weed management with modified soil tillage (Rasmussen, 2004; Pardo et al ., 2010), use of resistant cultivars, and modified sowing dates (Debaeke et al., 2009). Traditional knowledge and local wisdom must be used as a foundation in developing technology to realize productive agriculture on suboptimal land (Lakitan, 2014).

The combination of high-yielding varieties of maize and sustainable agricultural practices (SAPs) increases maize yield and smallholder income. Adoption of new high yield varieties of maize alone has a greater impact on maize yield, but the high cost of inorganic fertilizer causes profits to be low. Greater farmer income is derived from SAPs packages such as maize-legume rotation and residual retention (Manda et al., 2016). Application of nitrogen (N) through 50% (organic) + 50% (inorganic) maintained higher soil quality followed by application of 100% N through organics. Reduction in the intensity of tillage to 50% with intercultural practices and combined use of organic and inorganic fertilizers maintained higher soil quality in these degraded Inceptisols compared to inorganics alone (Sharma et al., 2014).

Several studies have shown a fairly good yield on low input treatment. Low input systems can reduce environmental damage than conventional systems (standards, recommendations), while reducing yield losses compared to organic systems. Maize cultivation in low input systems only uses 50% pesticides and mineral N is reduced by 36% but maize yields are no different from conventional systems, and are higher than yields in organic systems (Hossard et al., 2016). The best treatment combination for good soil health and higher yield in maize crop (5.5 t ha^{-1} grain yield) in alluvial soil at Allahabad region were 125 kg Roller 6 times + 50% RDF (NPK + ZnSO4) + FYM 5 t ha^{-1} But decreasing the treatment dose to 50% ie 125 kg Roller 3 times + 25% RDF (NPK + $ZnSO_4$) + Farm Yard Manure 2.5 t ha^{-1} can still produce 4.2 t ha^{-1} maize grain in alluvial soil (Pratap et al., 2016). The highest grain yield (8.37 t ha^{-1}) was found from the treatment of N 300 kg ha^{-1}, P 50 kg ha^{-1}, K 150 kg ha^{-1} and S 30 kg ha^{-1}. The lowest grain yield (7.33 t ha^{-1}) was obtained from treatment of P 50 kg ha^{-1}, K 150 kg ha^{-1}, and S 30 kg ha^{-1} (Mahamood, et al. 2016).

Fertilizing efficiency can also be achieved with the help of biological fertilizers as an important source of microorganisms to help fertilizer efficiency and soil health. According to Kumar et al. (2016), co-inoculation of three rhizobacteria (Enterobacter, M. arborescens and S. marcescens) performed best in the promotion of growth, yield, and nutrient (N, P, Cu, Zn, Mn, and Fe) uptake by wheat and improve the quality of acid sulfate soils. Haryono (2013) states that bio-fertilizers in acidic sulphate soils in South Kalimantan can increase soil pH by more than 40%, substitute lime needs above 80%, reduce sulfate levels by more than 20%, and increase rice productivity.

The treatment was arranged to reduce the need for chemical fertilizers by increasing efficiency or mining nutrients in the soil and testing local wisdom technology (use of manure, compost, burn ash, Local Liquid Organic Fertilizer (LLOF), or peat soils). The research aims to find a low input technology package for maize cultivation in suboptimal land in Riau Province.

2. Materials And Methods

The research was carried out on the overflow type C tidal agroecosystem, around the Mandau River on alluvial, peat, and mixed alluvial + peat soils in Siak district. Research time is from March to December 2018.

The materials used are hybrid maize varieties such as Nasa 29, Bima Uri 19, and composite maizes such as Bisma and Sukmaraga, Urea fertilizer, TSP, KCl, manure, dolomite, biological fertilizer, burn ash, decomposers, pesticides, and herbicides.

The study was conducted on farmer's land in three locations with different types of soil, namely: alluvial, peat, and mixed peat + alluvial. One experimental unit consists of 48 plots with the size of each plot 5 m x 8 m.

Tillage using a mini tractor and hoe, once plow and once rake. After tillage, drainage trenches are made around with the width of 40 cm and depth 30 cm.

The application of manure, dolomite lime, and M-Dec was carried out two weeks before planting. Lime and manure are sown on the surface of the soil on the path to be planted. In the experimental plot there are 10 lanes with a distance between 75 cm. The dosage of lime is 1 t ha^{-1} and dose of organic fertilizer is 2.5 t ha^{-1}. Furthermore, the path to be planted are doused with M-Dec (4 kg ha^{-1}) that has been dissolved in 400 liters of water. The fertilization and ameliorase packages tested are presented in Table 1.

Table 1. Fertilization and ameliorase packages

Treatment component	Fertilization and Ameliorase Packages			
	A	B	C	D
Urea (kg ha^{-1})	300	300	150	150
TSP (kg ha^{-1})	200	200	50	0
KCL (kg ha^{-1})	100	100	50	0
LLOF (liter ha^{-1})	0	400	400	0
Burn ash (kg ha^{-1})	0	500	500	0
Cow manure (kg ha^{-1})	2.500	2.500	2.500	0
Dolomite (kg ha^{-1})	1.000	1.000	1.000	500
Biological fertilizer	Agrimeth	Agrimeth	Agrimeth	Agrimeth

Maize seeds are planted at a spacing of 75 x 20 cm, one seed per planting hole. Insertion of non-growing plants is carried out 5 days after planting.

Biofertilizer is watered into the rooting area 2 times, ie: at 2 and 4 weeks after planting (WAP) with a spray volume of 400 l ha^{-1}. Urea, TSP and KCl fertilizer doses according to treatment. One third of the urea fertilizer, and all TSP and KCl fertilizers were given at planting and two-thirds of urea fertilizer was given at 4 weeks after planting (WAP). Biofertilizer is not given at the time of planting because the seeds have Saromyl fungicide webbed and when planting the planting hole is given carbofuran.

The 4-week-old maize was given fisrt supplementary fertilizer. Urea fertilizer as much as 2/3 of the treatment dose is sprinkled on the surface of the soil about 15 cm from the stem of the plant and then immediately covered with soil. Weeds that begin to grow among 7-days-old plants are controlled with selective herbicides. Harvesting is done when the cornhusk starts to dry or the seeds are dry, hard, shiny, and have a black layer.

LLOF is made from 100 kg of fresh cow manure, 1 kg of NPK, EM4 2 liters, 1 kg of granulated sugar, kitchen waste, and 200 liters of water. All ingredients are stirred evenly, tightly closed and fermented for 3 weeks. After 3 weeks, the lid is opened, the solution is stirred, then left open for 7-10 days to raise the pH. Burned ash is produced from burning wood and rice husks.

Experiments in each environment were designed using RCBD which was repeated three times. Physical and chemical analysis of the soil was carried out before the study by taking composite soil samples to a depth of 40 cm. Socio-economic data was obtained from implementing farmers and farming costs from each of the technologies introduced. The variables observed were: plant height, number of rows per ear, number of seeds per row, weight of 100 seeds, and yield.

Data analysis. Analysis of variance based on randomized complete block designs and further tests used a 5% LSD. Data analysis using STAR program. The yield stability of each variety in each environment was analyzed according to Finlay-Wilkinson (1963) using the PBSTAT program. To analyze the economics of maize farming in each development technology package using MBCR analysis. Mathematically farm income can be calculated by the formula:

$$\Pi = Y.Py - \Sigma X_i.Px_i - BTT$$

Annotation:

Π = Income (Rp)

Y = Yield (kg)

Py = Prices of yield (Rp)

Xi = Production factors (i= 1,2,3,…n)

Pxi = Price of the i-factor production (Rp)

BTT = Total fixed costs (Rp)

To find out whether farming is profitable or not economically analyzed using Benefit Cost Ratio according to Rustiadi et al (2011):

$$B/C = PT/BT$$

Annotation:

B/C = Ratio of benefit and cost

TR = Total Revenue (Rp)

TC = Total Cost (Rp)

The decision making criteria are as follows:

- if B/C > 1, then the farm experiences profits, income is greater than costs
- if B/C < 1, then the farm suffers a loss because the income is less than the cost
- if B/C = 1, then the farm gets even because the income equals the cost.

3. Results And Discussion

Biophysical Condition of Study Location

The research site is an abandoned land that was cleared for rice fields but due to biophysical inhibiting factors, the land was not managed by farmers. The soil is dominated by clay, loam, and partially peat. Dominant vegetations are Ottochloa nodosa (Kunth) Dandy, Melastoma candidum, imperata cylindrical, Eleocharis dulcis, Eleocharis ochrostachys Steud, and various small timbers. Under the peat layer is soft alluvial soil. In the rainy season, the surface of the ground water is shallow so that the soil quickly becomes mud. Topsoil layer is rather dark in color only 10-20 cm deep followed by a gray subsoil layer filled with iron rust. The topsoil layer is the remnants of peat that have been eroded during land clearing. Mixed soil of peat + alluvial in the form of small grains which is a mixture of peat and loam / dry clay. This soils are very porous so organic matter needs to be added. All soil react very acid. According to Armanto et al., (2016), the real problem of soil acidity is related to cation exchange capacity, soil organic matter and C / N ratio, soil nutrient balance, and potential toxicity.

Based on soil CEC status, base saturation value, organic matter content, and P-available, the alluvial substratum soil in the study site is classified as infertile, alluvial + peat mixture is infertile, and peat is infertile. Very low base saturation at all three locations (Table 2), indicates that the soil has experienced a lot of leaching and is infertile or poor soil base.

Table 2. Results of alluvial, alluvial + peat mixture, and peat soil analysis

Variable	Type of soils					
	Alluvial	Criteria	Alluvial+Peat	Criteria	Peat	Criteria
Texture (%)						
Sand	0.13		0.18		-	-
Loam	35.9		35.5		-	-
Clay	64.0		64.3		-	-
pH (1:2,5)						
H_2O	3.47	very acid	3.77	very acid	3.3	very acid
KCl	3.78	very acid	3.97	very acid	3.2	very acid
C-Organic (%)	1.93	Low	5.37	very high	13.10	very high
N Total (%)	0.31	Moderate	0.36	moderate	0.21	moderate
C/N	6.23	Low	14.8	moderate	62.38	very high
HCl 25% (ppm)						
P_2O_5	20.7	Moderate	240	very high	6	very low
K_2O	184	very high	442	very high	5	very low
P-Bray 2 (ppm)	6.85	Low	267	very high	8.70	moderate
CEC (me/100g)	29.0	High	48.8	very high	32.10	high
Exchange base cation (me/100g)						
K	0.18	Low	0.77	high	0.03	very low
Ca	0.40	very low	2.11	low	0.02	very low
Mg	0.29	very low	0.95	low	0.03	very low
Na	0.10	very low	0.28	low	0.04	very low
Base saturation (%)	3	very low	8	very low	0,37	very low
Exchangeable acidity KCl 1 N (me/100 g)						
H	<0.01	-	0.03	-	6.44	-
Al	15.7	Moderate	11.4	moderate	14.66	moderate
Extract Morgan Wolf (ppm)						
Fe	79.9	very high	78.4	very high		

Effect of Treatment Against Maize Yields and Yield Components

The results of analysis of variance in Table 3 show a very significant interaction between soil types, fertilizer packages, and varieties of all observed variables (P = 0.00). The yield is influenced by all sources: soil types, fertilizer packages, varieties, and interactions of soil types x fertilizer packages, soil types x varieties, fertilizer packages x varieties, and soil types x fertilizer packages x varieties. Interaction means that the yields obtained under the influence of varieties depend on the level of the fertilizer package or soil type.

Table 3. Pr (> F) values of treatments for various observed variables

Sources	Plant height	No.of row /ear	No.of seed /row	Weight of 100 seeds	Yield
Replication	0.0294	0.5466	0.4088	0.2610	0.6894
Soil types (ST)	0.0000	0.0000	0.0000	0.0000	0.0000
Fertilizer packages (FP)	0.0000	0.0000	0.0000	0.0000	0.0000
Varieties (V)	0.0000	0.8569	0.0049	0.0476	0.0008
ST * FP	0.0000	0.0000	0.0000	0.0000	0.0000
ST * V	0.0000	0.0017	0.0062	0.0000	0.0016
FP * V	0.1639	0.0021	0.0338	0.0005	0.0000
ST * FP * V	0.0001	0.0000	0.0040	0.0000	0.0000
CV (%)	6.30	8.30	11.32	6.39	16.97
Mean	163.79	11.22	22.53	25.41	3.73

All varieties produce good growth and yields in soil with better chemical properties, ie alluvial + peat (AP) mixture but yields are very low in soils that are chemically very poor, especially the low P-available, CEC, and C-organic content. The average growth and yield of the best varieties in all soil types and fertilizer doses produced by Nasa 29 were 4.0 t ha^{-1} and Sukmaraga were 3.9 t ha^{-1} dried seeds (Table 4).

All varieties responded well to the combination of AP soil with fertilizer package B (FPB) . Maize yields increased in all types of soil treated with FPB and yields dropped if the dose of chemical fertilizer was reduced by 50%. However, the decline in yield can still be tolerated if it is correlated to the amount of costs to buy another 50% fertilizer and economically disadvantages farmers.

In AP soil, the four varieties are potential developed by reducing the dose of chemical fertilizer (C) because the decreased maize yield is not extreme. Nasa 29 variety is better than other varieties in reducing the dose of chemical fertilizer. AP soil has C-organic, P-Bray and base saturation better than subsoil alluvial even though both have the same texture as dusty clay.

The response of Nasa 29 varieties to differences in soil environment and fertilization treatment is the best compared to other varieties. Nasa 29, which was planted on AP soil and treated with FPB, produced 8.63 tons ha^{-1} of dried seed. Reduction of chemical fertilizer dosage up to 50% as in Fertilizer Package C (FPC) only slightly decrease yield compared to decreases of yields in Fertilizer Package A (FPA) and Fertilizer Package D (FPD). The yields of Nasa 29 due to the reduction in the dose of chemical fertilizer from FPB to FPC are higher than other varieties, but the yields will be worse if the fertilizer dose continues to be reduced to FPD.

Reduction in the use of fertilizer on maize yields has been reported by Hossard et al. (2016), ie the average mineral N use was reduced 36% for maize in low input compared to conventional. Maize yields in low input systems are no different from those in conventional systems, and are higher than yields in organic systems (ratio of yields of low inputs vs organic = 1.24). Low input reduces yield loss compared to organic systems. A low input system can significantly reduce the application of pesticides, without strongly reducing crop yields, relative to conventional systems.

High yields in AP soils show better soil fertility. The combination of alluvial with thin peat produces soil with better physical and chemical properties. Good environmental conditions cause the prolific character of Nasa 29 variety to emerge by 42%, ie out of every 100 plant, 42 plants have double ears. This is not seen in other types of soil.

The lowest yield of all varieties was obtained on alluvial substratum. This soil contains very high iron and is very hard during drought. Maize grown in this location grows stunted. The low productivity of the soil is related to the low soil organic matter, soil is hard and compact so it is difficult to be penetrated by water, and high acidity, so that fertilizers which are given a lot cannot be absorbed properly by plants. The use of high doses of fertilizer under conditions of soil carrying capacity is not appropriate, such as in alluvial soils which have a very clayy texture, similar to the case of over dosage which causes a decrease in growth. Singh et al. (2017), states that overdoses of chemical fertilizers in agriculture in order to maximize the crop productivity have caused agronomic, environmental, economic, and health threats because about 50–70% of applied conventional chemical fertilizers get lost in the environment due to leaching, runoff, emissions and volatilization in soil, water, and water.

The poor alluvial environmental conditions in this study occurred due to land clearing that was not environmentally friendly. According to Armanto et al. (2016), landuse types, showed many changes in physical, chemical and biological aspects, and many limiting factors for growing of food crops, especially for rice, maize and others. The limiting factors are the depths of ground water levels and soil acidity.

Variation response of varieties on peat soils appears when treated with fertilizer packages A, B, and C. But in package D all varieties give very low yields and are not significantly different between varieties. On average, all varieties give higher yields in peat soils than in alluvial soils. The average yield reduction ratio of varieties due to reduction in chemical fertilizer doses on peat + alluvial, subsoil alluvial, and peat soils are 0.66, 0.92, and 0.73, respectively.

The minimum fertilizer dose (FPD) does not help production in all types of soil. Biological fertilizer may only help to provide a limited amount of nutrients that are bound in the soil. Fertilizers FPB and FPC in alluvial soils do not significantly increase or decrease yields. Increasing the dose of Urea fertilizer from 150 kg to 300 kg and KCl from 50 to 100 kg, and TSP from 50 kg to 200 kg ha^{-1} cannot increase yields significantly. It seems that the carrying capacity of organic matter, lime, and biological fertilizers provided is not enough to spur the absorption of chemical fertilizers given. Heavy clay and highly acidic requires more lime and organic matter. In this case, the application of FPC is more beneficial to farmers than FPB.

High yields due to fertilizer packages B and C are related to the influence of both LLOF and burned ash. High doses of chemical fertilizers and ameliorants as in FPA, are not able to provide high yields on AP or Alluvial soils because they are not given LLOF and burn ash, except on peat soils. The yields of other hybrid varieties Bima 19 Uri fell 1.97 t ha^{-1} from 6.87 t ha^{-1} to 4.90 t ha^{-1} on AP soils if chemical fertilizer was reduced by 50%. LLOF mungkin mengandung bio-effector yang berinteraksi dengan bahan organic atau menambah aktivitas pupuk hayati yang diaplikasikan sebelumnya. LLOF may contain bio-effectors that interact with organic material or increase the activity of biological fertilizers that were previously applied. Thonar et al. (2017) said that the efficiency of bio-effectors (BE) to increase maize growth and nutrient uptake is very different according to soil types and fertilizer combinations. Promising results are obtained from the combination of BE with organic fertilizer such as compost manure, organic waste, and sewage sludge. This BE effect is largely due to an increase in root growth and P mobilization through accelerated mineralization.

Without the LLOF component and burned ash in FPA, the Sukmaraga and Bisma composite varieties can grow both in AP and peat soils. In substratum alluvial soils, plant growth and yields are highly depressed despite being given high doses of chemical fertilizer if without LLOF and burned ash. The Sukmaraga variety also does not give an extreme response to the decrease in the dose of chemical fertilizers. This variety still produces 5.1 t ha^{-1} of dried seeds in the FPC in AP soil.

In subsoil of alluvial soils, the role of LLOF and burn ash in FPB and FPC is quite positive (yield > 3 t ha^{-1} dry seeds) compared without LLOF and burn ash in FPA (yields 1.5 t ha^{-1} dry seed). In alluvial soils, crop yields drop dramatically without LLOF and burn ash, despite the use of high-dose chemical fertilizers. Very heavy alluvial soil texture is not enough just 2.5 t ha^{-1} of organic matter. The addition of 400 liters of LLOF ha^{-1} and 500 kg ha^{-1} of burn ash increased the yield significantly. But in high C-organic soil conditions (alluvial + peat and peat), the effect of LLOF and burn ash is not significant because the yield of the treatment FPA is higher than the FPC. In alluvial + peat and peat soils, increasing the dose chemical fertilizer is more important than LLOF and burn ash.

Organic fertilizer is very important as a buffer of the physical, chemical, and biological properties of the soil so that it can increase fertilizer efficiency and land productivity. Organic fertilizer can make clay become loose, spur the development of microorganisms in the soil that can produce growth hormones and CO_2 for photosynthesis. Cow manure plays an important role in adding nutrients and accelerating the availability of nutrients for plants. Cow manure can increase aeration and reduce soil density and add soil organic matter. Liquid organic fertilizer will increase the availability of nutrients in the soil, affecting the growth and development of plant roots (Miguel et al., 2018). For barren soils, the provision of organic material + inorganic fertilizer increases microbial biomass which is much higher compared to the treatment of inorganic fertilizer. In addition, the use of native plants combined with organic material is very good for improving soil biological properties (Basanta, 2017).

Soil has a function as a source of nutrients and as a matrix where the roots anchor and ground water are stored. Plant growth does not only depend on adequate and balanced supply of nutrients but must also be supported by good soil physical conditions that directly influence the development of roots, water and soil air, soil biology and chemistry. Soils that contain too much clay can store a lot of water, but water does not easily seep into the soil or cannot penetrate the pores of the soil so that water will flow on the surface of the soil, cause erosion, and is not available to plants. The clay fraction acts more chemically in the soil because it is colloidal or electrically charged. Clay has low porosity characteristics, 35% -40% clay content, less support for root development and disturbs root respiration so it is less productive (Hanafiah, 2005). Heavy clay soils are globally widespread but their poor drainage and poor aeration limits are used for agriculture (Obia et al., 2018).

Table 4. Maize yields on soil types, fertilizer packages, and varieties

Soil types	Fertilizer	Yields (t ha^{-1})	Average soil

packages		Varieties				type and fertilizer packages
		Nasa 29	Bima 19 Uri	Sukmaraga	Bisma	
Alluvial + Peat	A	3,2 c	6,0 b	7,9 a	6,0 b	5.8
	B	8,6 a	6,9 bc	7,6 b	6,3 c	7.4
	C	6,2 a	4,9 b	5,1 b	3,5 c	4.9
	D	2,8 a	1,9 a	2,9 a	2,2 a	2.5
Average		5.2	4.9	5.9	4.5	
Alluvial	A	1,8 a	1,5 a	1,2 a	1,5 a	1.50
	B	4,0 a	2,7 b	3,2 ab	3,4 ab	3.33
	C	3,4 a	3,1 a	2,9 a	2,9 a	3.08
	D	2,2 a	2,2 a	2,5 a	2,6 a	2.38
Average		2.9	2.4	2.5	2.6	
Peat	A	4,4 ab	3,6 b	3,8 b	4,8 a	4.15
	B	5,6 a	4,5 b	4,5 b	4,5 b	4.78
	C	4,3 a	3,4 ab	3,4 ab	2,9 b	3.50
	D	1,5 a	1,6 a	2,0 a	1,3 a	1.60
Average		4.0	3.3	3.4	3.4	
Average of variety		4.0	3.5	3.9	3.5	

Note: Numbers followed by the same lowercase letters on the line mean that they are not significantly different according to LSD 5%.

Table 5. Yield components for combination of fertilizer packages and varieties in alluvial + peat soils

Fertilizer packages	Varieties	Yields	Number of row/ear	No. seeds /row	Weight of 100 seeds	Plant height (cm)
A	Nasa 29	3,20	11,3	29,7	25,8	203,0
	Bima 19 Uri	6,00	14,0	32,3	28,0	199,0
	Sukmaraga	7,93	15,3	34,0	33,1	243,7
	Bisma	6,03	14,0	31,3	30,5	200,0
B	Nasa 29	8,63	14,7	37,7	35,1	220,7
	Bima 19 Uri	6,87	14,0	33,3	30,5	217,0
	Sukmaraga	7,57	14,7	34,7	32,5	258,7
	Bisma	6,33	13,3	33,0	29,4	197,7
C	Nasa 29	6,23	12,0	34,3	29,8	187,0
	Bima 19 Uri	4,90	12,7	28,3	28,1	177,0
	Sukmaraga	5,07	12,0	30,3	28,7	229,7
	Bisma	3,47	10,0	29,0	23,8	174,7
D	Nasa 29	2,80	8,0	25,0	22,3	169,0
	Bima 19 Uri	1,93	8,0	23,7	20,8	152,7
	Sukmaraga	2,87	8,0	31,0	24,7	191,3
	Bisma	2,17	8,7	24,1	21,3	155,3

The role of burn ash on clay has been reported by Anikwe (2000), namely that rice husk dust 4.5 t ha^{-1} is better at repairing heavy clay soils than the dose of 6.0 t ha-1 by improving water transmissivity and soil aeration and then soil productivity. The highest average seed yield and plant height of maize were obtained in plots amended with 4.5 t ha^{-1} rice dust. RHD increases yields through improving soil physical properties such as soil dry bulk density, total porosity, penetration resistance, and saturated hydraulic conductivity.

Soil bulk density decreased to 4.69% with the treatment of 60% chemical fertilizer + bio fertilizer compared to 60% chemical fertilizer + organic matter. The treatment of 60% CF + BF significantly increases total soil nitrogen, P-available, K-available, soil organic carbon, dissolved organic carbon. The resistant enzymatic activities of catalase, peroxidase, polyphenoloxidase, and fluorescein were detected by bio-fertilizer addition, antagonistic bacterial abundance, suppressed pathogens (Li et al., 2017).

Table 6. Yield components of a combination of fertilizer packages and varieties in alluvial soils

Fertilizer packages	Varieties	Yields	Number of row/ear	Number of seeds/row	Weight of 100 seeds	Plant height (cm)
A	Nasa 29	1,82	8,7	14,3	22,9	140,7
	Bima 19 Uri	1,52	8,0	14,0	22,5	120,3
	Sukmaraga	1,20	8,0	13,3	20,9	117,3
	Bisma	1,50	8,7	12,0	21,0	115,0
B	Nasa 29	4,07	12,0	26,3	25,9	150,0
	Bima 19 Uri	2,73	8,0	19,0	23,1	149,0
	Sukmaraga	3,18	8,7	20,0	22,7	174,7
	Bisma	3,42	10,7	16,0	26,4	119,3
C	Nasa 29	3,33	10,7	16,0	22,9	131,0
	Bima 19 Uri	3,13	10,0	14,0	22,6	136,3
	Sukmaraga	2,90	8,0	14,3	21,2	158,7
	Bisma	2,88	9,3	14,7	21,5	123,7
D	Nasa 29	2,25	8,7	13,3	20,5	99,7
	Bima 19 Uri	2,18	10,7	13,3	21,2	96,0
	Sukmaraga	2,45	11,3	16,0	23,6	119,3
	Bisma	2,62	11,3	16,0	24,7	105,0

Based on the Finlay-Wilkinson stability analysis, Nasa 29 and Bima 19 Uri have a regression coefficient close to 1 (bi = 1), indicating that the variety is stable or widely adapted in all environmental combinations of soil types and fertilizer treatments (Table 8). According to Eberhart and Russel (1966), a genotype is stable if it has regression coefficient (bi) of 1.0 and deviation of the regression coefficient equals zero. Genotypes with a regression coefficient significant less than 1.0 (bi <1) will adapt to either the suboptimal environment or not sensitive to environmental changes. Thus, if the input provided is not optimal due to limited capital availability, the yield of Nasa 29 and Bima 19 Uri do not extreme reduced. These varieties can be planted in suboptimal locations with low input.

Table 7. Yield components of a combination of fertilizer packages and varieties on peat soils

Fertilizer packages	Varieties	Yields	Number of row/ear	Number of seeds/row	Weight of 100 seeds	Plant height (cm)
A	Nasa 29	4,44	12,0	20,7	28,8	184,0
	Bima 19 Uri	3,62	12,7	16,7	30,5	178,0
	Sukmaraga	3,77	12,7	20,3	24,6	205,3
	Bisma	4,81	12,7	26,0	26,7	175,0
B	Nasa 29	5,62	13,3	24,3	29,0	182,0
	Bima 19 Uri	4,51	14,0	23,3	28,7	183,0

	Sukmaraga	4,50	12,7	26,0	29,1	206,7
	Bisma	4,47	13,3	26,3	27,7	186,3
C	Nasa 29	4,34	12,0	21,7	26,1	169,0
	Bima 19 Uri	3,43	12,0	23,7	26,8	163,0
	Sukmaraga	3,46	13,3	25,0	26,7	159,7
	Bisma	2,88	14,0	23,3	26,2	152,0
D	Nasa 29	1,53	10,7	15,0	20,3	109,0
	Bima 19 Uri	1,55	10,0	14,7	19,7	128,3
	Sukmaraga	1,97	10,0	14,7	21,5	144,7
	Bisma	1,35	10,0	15,3	19,4	103,7

Tabel 8. Finlay-Wilkinson Stability Analysis for YIELD

Genotype	Yield	b_i
Nasa 29	4.02	1.01
Bima 19 Uri	3.53	0.98
Sukmaraga	3.90	1.13
Bisma	3.49	0.88

The benefitable minimum treatment

In general, farmers expect high yields from farming, but weak economic conditions often lead to desires not being reached because they are unable to provide production facilities such as fertilizers and pesticides. According to Grassini et al. (2015), a maize crop that produces about 13 t ha^{-1} grain absorbs 200 kg of N. Relatively high amounts of resources must be absorbed by the crop to achieve high yields.

The results of this study indicate that the opportunity to reduce fertilizer doses depends on the type of soil to obtain yields that are low but still provide benefits for farmers. FPC and FPD were reviewed to consider the highest yield at a 50% chemical fertilizer dose. Variety Nasa 29 produced 6.23 t ha^{-1} of dried seeds in FPB, giving a profit of Rp 12,418,000 (Table 10).

Table 9. Yields of several varieties on fertilizer packages C and D in three soil types

Varieties	Alluvial		Alluvial + peat		Peat	
	FPC	FPD	FPC	FPD	FPC	FPD
Nasa 29	3.30	2.23	6.23	2.80	4.33	1.53
Bima 19 Uri	3.13	2.17	4.90	1.93	3.43	1.57
Sukmaraga	2.90	2.47	5.07	2.87	3.43	1.97
Bisma	2.90	2.63	3.47	2.17	2.87	1.30

Maize plants adapt widely to diverse environments, but not all locations can provide benefits in maize farming. Environmental differences require different investments in several stages of farming activities ranging from land preparation to harvest. Infertile land only produces 1.5 t ha^{-1} dry seeds. If it is associated with cost, then maize farming in an unfavourable location will cause a loss of Rp 3,848,000.

Maize farming in new opening tidal land is faced with environmental variations, therefore it is necessary to be careful in applying the technology package. Generalizing technology packages for each type of environment can cause harm.

The profit of using fertilizer does not only depend on the price and usefulness of fertilizer, but also on the efficiency of fertilizer use. According to Xu et al (2006), the response of maize yields to nitrogen indexes in various soil types and pH levels, shows that the marginal product of the nitrogen index is highest for groups of households that get fertilizer on time and use animal power or machinery for soil preparation . In addition, the interest rate on loans if farmers apply for loans to buy fertilizer, also affects the benefits of using fertilizer. No clear patterns are found in terms of nitrogen response rates being systematically higher (or lower) for a particular combination of agro-climatic zones, soil types and pH.

Table 10. Analysis of maize farming with fertilizer package C

No	Variable	Unit	Volume	Unit price (Rp)	Total (Rp)
A	**COSTS (C)**				**13.748.000**
1	Main and Supporting Materials				**6.508.000**
	Composite maize seeds	kg	15	14.000	210.000
	Organic fertilizer	kg	2500	1.000	2.500.000
	Dolomite Lime	kg	1000	1.000	1.000.000
	Urea	kg	150	5.300	795.000
	TSP	kg	50	6.000	300.000
	KCL	kg	50	6.000	300.000
	Gramoxone	l	5	75.000	375.000
	Saromyl	gr	30	1600	48.000
	Dithane	kg	2	100.000	200.000
	Selective herbicide	l	1	350.000	350.000
	Biofertilizer, biodecomposer	kg	4	40.000	160.000
	Prevaton 250 ml	botol	2	135.000	270.000
2	Labor Wages				6.240.000
	Soil tillage	OH	20	80.000	1.600.000
	Planting	OH	15	80.000	1.200.000
	Fertilization	OH	4	80.000	320.000
	Weeding	OH	9	80.000	720.000
	Maintenance (irrigation, pest control, supplementary fertilizers, seasonings, etc.)	OH	20	80.000	1.600.000
	Yield processing	OH	10	80.000	800.000
3	Fixed cost				1.000.000
B	**YIELDS**	Kg	6230	4200	**26.166.000**
C	**BENEFITS (B)**				**12.418.000**
D	**B/C**				**1,9**

Table 11. Analysis of maize farming with fertilizer package D

No	Variable	Unit	Volume	Unit price (Rp)	Total (Rp)
A	**COSTS (C)**				**10.148.000**

1	Main and Supporting Materials				**2.908.000**
	Composite maize seeds	Kg	15	14.000	210.000
	Dolomite Lime	Kg	500	1.000	500.000
	Urea	Kg	150	5.300	795.000
	Gramoxone	L	5	75.000	375.000
	Saromyl	Gr	30	1600	48.000
	Dithane	Kg	2	100.000	200.000
	Selective herbicide	L	1	350.000	350.000
	Bio-fertilizer, biodecomposer	Kg	4	40.000	160.000
	Prevaton 250 ml	botol	2	135.000	270.000
2	Labor Wages				**6.240.000**
	Soil tillage	OH	20	80.000	1.600.000
	Planting	OH	15	80.000	1.200.000
	Fertilization	OH	4	80.000	320.000
	Weeding	OH	9	80.000	720.000
	Maintenance (irrigation, pest control, supplementary fertilizers, seasonings, etc.)	OH	20	80.000	1.600.000
	Yield processing	OH	10	80.000	800.000
3	Fixed cost				**1.000.000**
B	**YIELDS**	kg	2870	4200	**12.054.000**
C	**BENEFITS (B)**				**1.906.000**
D	**B/C**				**1,18**

4. Conclusion

Reducing the dose of chemical fertilizer can be done to improve the ability of farmers to buy fertilizer depending on the type of soil and the availability of LLOF and grilled ash. Mixture of peat and alluvial is good soil for maize growth if combined with fertilizer package B. Decrease in chemical fertilizer 50% (package C) causes yields to fall to 6.23 t ha^{-1} and farmers get a profit of Rp 12,418,000 per planting season.

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