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Effect of Slopes and Compound NPK Fertilizer on Growth and Yield of Maize Local Varieties, RAE and EFE in Indonesia

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Nurdin <nurdin@ung.ac.id>
kepada submission

Sen, 18 Mei 2020 21.32

Dear Editor in Chief, RJOAS

Peace be with all of us
I hereby submit a research article entitled Effect of Slopes and Compound NPK Fertilizer on Growth and Yield of Maize Local Varieties, RAE and Inceptisol Bumela of Indonesia.
Hopefully get an encouraging response to its publication.

Regards
Nurdin

Effect of Slopes an...

EFFECT OF SLOPES AND COMPOUND NPK FERTILIZER ON GROWTH AND YIELD OF MAIZE LOCAL VARIETIES, RELATIVE AGRONOMIC AND ECONOMIC FERTILIZER EFFECTIVENESS TO INCEPTISOL BUMELA, INDONESIA

Nurdin*
Doctorate Program of Agriculture Science, Brawijaya University, Veteran street 65145 Malang, Indonesia.

Mochtar Lutfi Rayes, Soemarno, Sudarto
Department of Soil Science, Faculty Agriculture, Brawijaya University, Veteran Street 65145 Malang, Indonesia.

Nikmah Musa, Muhajir Dunggio
Department of Agrotechnology, Faculty of Agriculture, Gorontalo State University, Genderal Sudirman Street 96122 Gorontalo, Indonesia

*Email: nurdin@ung.ac.id

ABSTRACT
Maize cultivation has been carried out on the mountainous slopes with high fertilizer inputs, but maize productivity is still low. This study investigates the effect of slope and NPK compound fertilization as well as the best combination of growth and yield of local maize, relative agronomic effectivness (RAE) percentages and economik fertilizer effectiveness (EFE) ratio in Inceptisol Bumela, Indonesia. Slope variations (0-8, 8-15, 15-35, >35%) are combined with compound NPK fertilizer levels (0, 50, 100, 150, 200 kg/ha) with split plot design. Growth data was recorded for changes in plant height and leaves number from 7 DAP to 42 DAP, while yield and yield components are recorded at harvest. The results showed that slope and NPK compound fertilization can increase the growth and yield of maize plants. The combination of flat slopes and fertilizer level of 100 kg/ha was the best combination in increasing plant height and the leaves number, accelerate the age of male and female flowering flowers, cob weight, grain yield and percentage of cob weight to grain yields. This combination was also able to increase the percentage of RAE, the ratio of EFE subsidized and non-subsidized. If farmers will continue to cultivate maize on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg/ha only.

KEY WORDS: Slope, fertilizer, NPK compound, growth, yield, maize.

Maize is an excellent commodity in Gorontalo province of Indonesia. Gorontalo Province maize production until 2018 has reached 1.7 million tons or increased by 9.3% from the previous year with a productivity of 5.0 ton/ha (BPS, 2019) which places Gorontalo Province as one of the largest maize producers in Indonesia (Yunus et al., 2018). Maize was cultivated from generation to generation by local farmers (Ardiani, 2009; Fadhilah, 2013) using maize local varieties. However, since 2002 through the agropolitan programs with maize commodity (Jocom et al., 2009; Grace, 2010), the use of local varieties has changed to maize hybrid and composite varieties, so as the maize local variety were rarely planted and threatened with extinction.

One of Gorontalo's local germplasm was the Motoro Kiki variety (Zubachtirodin and Kasim, 2012). Motoro Kiki is a Gorontalo maize local variety (Yasin et al., 2007) that aged 70-80 day after planting (DAP), yield potential was 3 ton/ha of grain yield, resistant to downy mildew and leaf rust, and was well planted in the lowlands to the highlands (IAARD, 2009). Maize local has better growth than hybrid and maize composite, but the yield component shows the opposite patterns (Kaihatu and Pesireron, 2016).

Maize cultivation in Gorontalo Province region was very massive and has carried out on upland with a slope of 0% (flats) to mountainous land (slope >35%) which was vulnerable to land degradation. In fact, soil erosion that occurred from the Agropolitan maize planting area reported by Husain et al., (2004) as many as 1.396 ton/ha/year. If this condition was left, it will threaten the sustainability of maize farming. Upland for maize cultivation in Bumela Village was generally on Inceptisol (Indonesian Soil and Agroclimate Research Center Team, 1995). Inceptisol was a relatively young soil and its development was a level above of the Entisols (Rachim, 2007), including having a cambic horizons with a percentage of Na can be exchanged by 15% or more (Soil Survey Staff, 2014). Inceptisol has the potential to be developed (Nursyamsi et al., 2002; Hermawan et al., 2018) because it covers 70 million hectare in Indonesia (Kasno, 2009; Muyassir et al., 2012; Hermawan et al., 2018). However, these soils generally have low soil fertility and organic matter content (Abdurachman et al., 2008; Arviandi et al., 2015). Meanwhile, the high intensity of tillage for maize cultivation has led to a decrease in soil fertility (Lorenz et al., 2000; Husain et al., 2002; Pomalingo and Husain, 2003), so as the maize productivity is low, although fertilizer application exceeds recommendations.

A literature study on the results of the effect of slope and compound NPK fertilization combined with the specific growth and yield of maize local variety has not been found. While information on the performance of growth and yield of maize local on various slopes combined with the level of NPK compound fertilization is very important for farmer and policy maker, especially in the Gorontalo Province. In fact, maize farmers continue to cultivate on sloping land of >25% with less fertilizer input or exceed the recommended fertilizer levels, so this research was important to done. This study aims to investigate the growth and yield of maize local variety of Motoro Kiki, the relative agronomic effectiveness (RAE) and economic fertilization effectiveness (EFE) on various slopes and NPK compound fertilization to Inceptisol Bumela, Indonesia.

MATERIAL AND METHODS

Site study area

The study was conducted to four months (December 2019 to March 2020) on the toposequence of farmers maize land in Bumela Village, Bilato District, Gorontalo Regency, Gorontalo Province, Indonesia. Specifically geographical, the experimental field was rectangular located at $0^0$36'11.98"-$0^0$36'11.46" N and $122^0$40'01.33"-$122^0$40'02.49" E at an altitude of 314 m asl, and $0^0$36'08.39"-$0^0$36'08.11" N and $122^0$40'00.31"-$122^0$40'01.45" E with an altitude of 339 m asl.

Table 1-Some soil physico-chemical properties were selected at a depth of 0-30 cm

No	Soil properties	Value	Criterion*
1.	Textures:		
a.	Sand (%)	62.00	Sandy clay
b.	Silt (%)	21,50	
c.	Clay (%)	16.60	
2.	pH (H2O	5,65	Rather sour
3.	Soil organik carbon (%)	0.67	Very low
4.	Total nitrogen (%)	0,07	Very low
5.	P-Bray 1 available (mg/ka)	4.02	Low
6.	Cations exchangeable:		
a.	K^+	0.29	Low
b.	Na^+	2.16	Low
c.	Ca^{2+}	3.86	Low
d.	Mg^+	0,38	Low
7.	Cation exchange capacity (cmol/kg)	8.94	Low
8.	Base saturation (%)	79,88	High
9.	Na saturation (%)	24,27	High

**Eviyati and Soleman (2009).*

This soil is very dark gray brown (10YR 3/2), granular of soil structure and sandy clay of texture, cation exchange capacit of 8.94 cmol/kg and base saturation 79.88%, Na saturation of 24.17% (Table 1). Annual average rainfall of 1,245.90 mm with annual average temperature of 28.02ºC and potential evapotranspiration of 152.95 mm, so the soil moisture regime was Ustic (106 dry days without humid days) and the soil temperature regime was Isohiperthermik. Based on the soil morphology, physicochemical properties and other properties soils, the soil in the experimental field was classified as Oxic Humustepts (Soil Survey Staff, 2014).

Research material

The compound fertilizer used was NPK Phonska fertilizer with nutrient content (%) of 15-15-15 and Gorontalo maize local was used Motoro Kiki variety. The land was used upland owned by maize farmers with Inceptisol (Oxic Humustepts) soil type. This upland was used starting from flate (0-8%), unduleting (8-15%), hills (15-35%) and mountainous land (> 35%) on one toposequency.

Field experimentals

The field experimental are designed following a split plot design. Four slope treatments were slope of 0-8% (S1), 8-15% (S2), 15-35% (S3) and slope >35% (S4) as the main plots. While the five NPK compound fertilizer treatments, namely 0 kg/ha (F0), 50 kg/ha (F1), 100 kg/ha (F2), 150 kg/ha (F3), and the level of 200 kg/ha (F4) as subplots. Each treatment was repeated three replication, so as 60 treatment plot combinations were obtained. The treatment plot was made 2 x 2 m by smoothing the soil evenly with hoe and shovel. The distance between plots was made 1 m to facilitate accessibility to and from the treatment plot.

Maize was planted with a distance of 20 x 40 cm in the planting hole of 2 maize seeds (December 26, 2019), so as to get 50 plant populations per plot. At the maize age of 7 day after planting (DAP), weed cleansing and thinning into 1 plant per holes. The first fertilization was done (1/2 level of fertilization per treatment) and plant embellishment was followed. Weed cleansing and embellishment was done when growing weeds manually with a hoe. At the maize age of 30 DAP, the second fertilization (the remaining 1/2 level of fertilization per treatment) was continued with plant embellishment. Maintenance continues until the harvest stage. Maize harvesting was done when the physical condition of the maize was dry and yellows (26 March 2020) or ± 90 DAP.

Observation of maize growth variables, including plant height (cm) and leaves number was carried out from plants aged 7 DAP to male flowers (± 42 DAP) on ten selected plants per plot. While the maize yield variables, including age of male and female flowering (DAP) were observed when maize flowers first appeared, the cob weight (ton/ha) was weighed after the maize seeds were separated from the cob, the grain yield (ton/ha) was weighed after the maize seeds were dried under 5 days sun exposure (± 15% moisture content) and the percentage of cob weight to grain yields (%).

Data analysis

NPK compound fertilizer applied, either singly or in combination was tested by relative agronomic effectiveness or RAE (Mackay et al., 1984; Chien, 1996) with the following equation:

$$RAE = \frac{Yt - Yo}{Ys - Yo} \; x \; 100$$

Where: Yt = maize yield on the tested fertilizer (ton/ha), Ys = maize yield standard (ton/ha), and Yo = maize yield on the control treatment (ton/ha). The greater the percentage of RAE, the better the effectiveness of fertilizer relative to agronomic traits. Meanwhile, to find out the fertilizer used has a good economic value, an economic fertilizing effectiveness (EFE) was carried out with the following equation:

$$Ratio\ EFE = \frac{P\ x\ Q}{C}$$

Where: P = price of maize per kg (IDR/Kg), Q = total yield (kg/ha), and C = price of fertilizer (IDR/Ha). If the EFE ratio was >1, the fertilizer tested has good economic value (Saeri and Suwono, 2012; Wijaya et al., 2015).

The price of maize per kg in the study area was IDR 3.500. While the price of Phonska compound NPK fertilizer consists of two, namely NPK Phonska was subsidized by the government at a price of IDR 2.300 and non-subsidized at a price of IDR 8.000. The two forms of NPK fertilizer were used as a comparison material as well as consideration in making the best agronomic and economical NPK compound fertilizer selection decisions. All data obtained were analyzed with ANOVA of split plot design divided into patterns 4^5. If there was a treatment that has a significant effect, then it was continued with the Duncan Multiple Range Test (DMRT) at the test level P >0,05 with the tools of the Statistical Analysis System (SAS) program.

RESULT AND DISCUSSION

Effect of slope and NPK compound fertilizer on maize growth

Slopes and NPK compound fertilization showed has significant effect on the plant height at the age of 14, 21, 28, 35, and 42 DAP, except at the age of 7 DAP in all treatments and at the age of 14 DAP in the treatment of compound NPK fertilizer that has not significantly affected (Tabel 2).

Table 2-The average of plant height of maize local of Motoro Kiki varieti due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Plant Heigh (cm)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	16.37 ± 0.40ns	33.28 ± 1.89ab	79.70 ± 4.31c	95.92 ± 6.48b	137.33 ± 4.49c	180.87 ± 10.48b
S2 (8 – 15%)	16.06 ± 0.38	34.97 ± 1.87b	69.99 ± 4.32b	83.90 ± 8.08a	120.67 ± 11.47ab	160.46 ± 13.22a
S3 (15 – 35%)	16.13 ± 0.40	32.36 ± 0.87a	63.41 ± 2.89a	89.26 ± 3.13a	113.94 ± 3.97a	159.33 ± 8.48a
S4 (>35%)	16.05 ± 0.62	33.02 ± 1.23ab	68.77 ± 2.93b	99.01 ± 5.19b	127.07 ± 7.89b	160.52 ± 9.95a
NPK Compound (F):						
F0 (0 kg/ha)	16.45 ± 0.48ns	34.00 ± 0.65ns	69.80 ± 4.68ab	88.57 ± 11.43a	117.13 ± 12.57a	150.65 ± 10.18a
F1 (50 kg/ha)	15.97 ± 0.17	33.31 ± 2.09	70.32 ± 8.59ab	92.70 ± 6.39ab	124.86 ± 10.99abc	164.78 ± 15.32b
F2 (100 kg/ha)	16.33 ± 0.39	34.33 ± 2.88	72.38 ± 9.92b	96.53 ± 5.90b	131.45 ± 12.71c	173.05 ± 14.53b
F3 (150 kg/ha)	15.97 ± 0.66	32.22 ± 0.71	66.72 ± 5.81a	88.65 ± 7.05a	121.95 ± 8.25ab	168.51 ± 7.38b
F4 (200 kg/ha)	16.02 ± 0.36	33.16 ± 1.20	73.10 ± 6.42b	93.65 ± 10.16ab	128.36 ± 11.33bc	169.47 ± 11.83b
Combinations (SF):						
S1F0	16.35 ± 0.49ns	33.55 ± 3.18abcd	76.55 ± 8.70abc	100.00 ± 17.11abc	134.50 ± 12.45abcd	163.95 ± 12.52cdef
S1F1	15.85 ± 0.92	32.75 ± 0.35abcd	81.75 ± 1.48ab	98.90 ± 1.84abcd	139.80 ± 5.66ab	187.65 ± 9.69ab
S1F2	16.50 ± 0.42	36.40 ± 4.81ab	84.45 ± 6.29a	102.70 ± 3.39ab	143.50 ± 7.07a	190.60 ± 6.93a
S1F3	16.95 ± 3.89	31.65 ± 5.30bcd	73.95 ± 13.79abcd	89.55 ± 18.60bcde	132.00 ± 4.38abcde	178.75 ± 13.22abcd
S1F4	16.20 ± 1.13	32.05 ± 2.90bcd	81.80 ± 4.53ab	88.45 ± 1.63bcde	136.85 ± 4.31abc	183.40 ± 3.54abc
S2F0	16.20 ± 0.00	34.40 ± 5.37abcd	67.45 ± 8.56cdef	73.30 ± 10.89f	107.30 ± 13.01h	139.20 ± 13.15g
S2F1	16.20 ± 1.13	36.35 ± 2.90abc	71.50 ± 3.54bcdef	85.10 ± 3.54cdef	118.10 ± 2.97defgh	158.15 ± 2.76efg
S2F2	16.55 ± 0.21	37.20 ± 3.68a	76.15 ± 1.63abc	95.70 ± 1.27abcde	138.95 ± 16.33ab	174.45 ± 16.19abcde
S2F3	15.60 ± 1.56	32.40 ± 0.42abcd	64.70 ± 1.98cdef	81.10 ± 1.41ef	120.90 ± 7.64cdefgh	165.55 ± 2.05cdef
S2F4	15.75 ± 0.21	34.50 ± 1.13abcd	70.15 ± 6.01bcdef	84.30 ± 3.82def	118.10 ± 10.89defgh	164.95 ± 2.90cdef
S3F0	16.10 ± 0.42	33.35 ± 2.76abcd	66.05 ± 1.48cdef	87.30 ± 0.99cdef	108.50 ± 1.27gh	148.95 ± 4.60fg
S3F1	16.00 ± 0.00	31.55 ± 2.05cd	61.80 ± 10.18ef	89.85 ± 3.89bcde	115.30 ± 3.68efgh	158.40 ± 10.75efg
S3F2	16.55 ± 0.78	31.50 ± 0.99d	62.20 ± 3.54def	88.80 ± 2.97bcde	114.90 ± 2.69efgh	172.05 ± 8.70abcde
S3F3	15.55 ± 1.06	33.15 ± 1.06abcd	60.15 ± 3.32f	86.10 ± 0.28cdef	111.90 ± 0.57fgh	161.45 ± 4.88def
S3F4	16.45 ± 1.06	32.25 ± 2.90bcd	66.85 ± 1.63cdef	94.25 ± 2.76abcde	119.10 ± 0.99defgh	155.80 ± 0.85efg
S4F0	17.15 ± 0.78	34.70 ± 0.57abcd	69.15 ± 3.04cdef	93.70 ± 5.66abcde	118.25 ± 14.07defgh	150.50 ± 7.50fg
S4F1	15.85 ± 0.35	32.60 ± 1.13abcd	66.25 ± 2.62cdef	96.95 ± 5.87abcd	126.25 ± 12.52abcdefg	154.95 ± 1.77efg
S4F2	15.75 ± 0.35	32.25 ± 2.33bcd	66.75 ± 4.17cdef	98.95 ± 5.16abcd	128.45 ± 13.65abcdef	155.10 ± 11.60efg
S4F3	15.80 ± 0.28	31.70 ± 0.42bcd	68.10 ± 5.94cdef	97.85 ± 7.57abcd	123.00 ± 8.91bcdefgh	168.30 ± 7.21bcdef
S4F4	15.70 ± 0.57	33.85 ± 1.48abcd	73.60 ± 3.54abcde	107.60 ± 14.42a	139.40 ± 28.43ab	173.75 ± 27.08abcde
CV (%)	7.18	5.88	6.93	6.75	5.84	5.05

Mean ± standard deviation, DAP: day after planting, ns: not significant, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

This was be fathomed because it was not directly related to the plant physiological aspects, but directly related to soil characteristics. Slopes were closely related to the quantity of soil organic carbon, total N, and enzyme activity by changing the rate of litter

decomposition and soil microbial activity (Nahidan et al., 2015). The highest rate of plant height increase at the age of 28 DAP with an average percentage of plant height increase of 111,05% in all treatments and decreased until the age of 42 DAP. While, the highest rate of plant height increase with an average percentage of plant height increase of 70,56% was indicated by the slope 0% (flat) and NPK compound fertilizer as much as 50 kg/ha, while the rate of plant height increase was lowest with an average percentage of plant height increase of 58.12% only was shown by the slopes >35% (mountainous) and NPK compound fertilizer as much as 0 kg/ha.

Apparently, the effect of slopes began to be seen clearly in plant height from the age of 14 DAP to 42 DAP, where the flat slope had a significant effect on plant height and the peak effect of the slope was more pronounced at plant height aged of 35 and 42 DAP, followed by a undulating slope. The position of the slope has a significant effect on the maize growth (Changere and Lal, 1997). Hilly and mountainous slopes will receive more sunlight than undulating and flat slopes, so that decomposition of organic matter and nutrient cycling was better. Humidity is a basic environmental factor in a relatively dry area, so higher humidity at the shady slopes location can lead to better nutrition cycles and higher microbial community activity (Xue et al., 2018). The levels of C-organic, total N, P are available and K can be exchanged at the study site is relatively low (Table 1), so fertilizing action was needed. While the effect of NPK compound fertilizer began to be seen clearly in plant height later on from the age of 21 DAP to 42 DAP, where the fertilizing level of 100 kg/ha showed the highest plant height from the age of 28 DAP, 35 and 42 DAP, but it was not significantly different from the fertilizer level of 50 kg/ha and 200 kg/ha at the age of 21 DAP, 28, 35 and 42 DAP, except with fertilizer levels 0 kg/ha and 150 kg/ha were significantly different at the age of 28 DAP and 35 DAP. The NPK fertilization has a significant effect on the agronomic parameters of maize (Achiri et al., 2017). Nitrogen is another important soil nutrient that affects plant growth and water use efficiency (Sardans et al., 2008). The application of Phosphor fertilizer increases the efficient utilization of N fertilizer on the production of maize biomass (Mensah and Mensah, 2016). Potassium is needed for maize growth (Solihin et al., 2019).

The combination of slopes and NPK compound fertilizers began to showing a significant effect on plant height aged of 14 DAP to 42 DAP, while at age of 7 DAP had no significant effect (Table 2). The combination of flat slope (0-8%) to undulating slope (8-15%) with NPK fertilizer compound level of 100 kg/ha shows the highest plant height at the age of 21 DAP to 42 DAP. While on a combination of hilly slopes (15-35%) and mountainous slopes (35%) with all levels of fertilization was relatively varied. However, if the lands with these slopes will still be used for maize cultivation, then it will be sought only to land with hilly slopes (15-35%) combined with NPK compound fertilizer levels of 100 kg/ha because plant height reaches of 174,45 cm at age of 42 DAP. At low fertilization rates, the amount of N and K absorbed by plants increases with the amount of fertilizer applied (Niu et al., 2013). Maize plants absorb large amounts of N from the soil at V6 and maximum absorption occurs before silking (Ma' et al., 2003).

The effect of the slope on the leaves number shows the significant effect from the age of 7 DAP to 42 DAP, while the effect of compound NPK fertilization shows the significant effect later starting at age of 21 DAP to 42 DAP (Table 3). The highest rate of leaves number increasing occurred at the age of 14 DAP with an average percentage of leaves number increase of 79.70% in all treatments and decreased until the age of 42 DAP. The rate of increasing the leaves number with an average percentage leaves number increase by 38.16% was indicated by the slopes >35% (mountainous) and NPK compound fertilizer as much as 150 kg/ha, while the rate of increasing the leaves number with an average the percentage of leaves number increase was 29,94% only, as indicated by the slopes 15-35% (hilly) and NPK compound fertilizer as much as 200 kg/ha. Leaves number of maize increased significantly as the plants aged with NPK

fertilizing (Titah et al., 2016). Effect of slope on the leaves number at age of 7 DAP shows the highest leaves number on hilly slopes (15-35%) and not significantly different from flat slopes (0-8%) and undulating slopes (8-15%), but significantly different from slopes mountainous (>35%). At the age of 14 DAP, the effect of hilly slopes still shows the highest leaves number and was significantly different from flat slopes and undulating slopes, while those with mountainous slopes are not significantly different. At the age of 21 DAP and 28 DAP, the effect of flat slope has shown the highest leaves number and was significantly different from all slope classes, except at the age of 28 DAP which was only significantly different from hilly slopes. While at the age of 35 DAP and 42 DAP, the effect of mountainous slopes shows the highest leaves number and was not significantly different from flat slopes.

Table 3-The average of number leaves of maize local of Motoro Kiki variety due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Leaves Number (strands)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	3.26 ± 0.12b	5.33 ± 0.09a	8.32 ± 0.38a	9.68 ± 0.52b	10.99 ± 0.23c	12.24 ± 0.38bc
S2 (8 – 15%)	3.22 ± 0.08b	5.78 ± 0.20b	8.00 ± 0.15b	9.40 ± 0.38b	10.49 ± 0.48b	11.70 ± 0.46a
S3 (15 – 35%)	3.34 ± 0.15b	6.02 ± 0.22c	7.91 ± 0.18b	9.07 ± 0.29a	10.22 ± 0.28a	12.02 ± 0.40b
S4 (>35%)	2.99 ± 0.11a	5.83 ± 0.06bc	7.90 ± 0.29b	9.50 ± 0.34b	11.01 ± 0.33c	12.51 ± 0.53c
NPK Compound (F):						
F0 (0 kg/ha)	3.22 ± 0.06ns	5.70 ± 0.32ns	7.73 ± 0.21a	8.88 ± 0.25a	10.22 ± 0.41a	11.43 ± 0.25a
F1 (50 kg/ha)	3.15 ± 0.15	5.87 ± 0.31	8.18 ± 0.55b	9.48 ± 0.54b	10.55 ± 0.54b	12.21 ± 0.51b
F2 (100 kg/ha)	3.23 ± 0.23	5.70 ± 0.20	8.07 ± 0.22b	9.63 ± 0.43b	10.93 ± 0.27c	12.38 ± 0.19b
F3 (150 kg/ha)	3.13 ± 0.21	5.65 ± 0.29	8.06 ± 0.02b	9.51 ± 0.23b	10.87 ± 0.48c	12.33 ± 0.24b
F4 (200 kg/ha)	3.26 ± 0.22	5.77 ± 0.44	8.10 ± 0.15b	9.53 ± 0.28b	10.80 ± 0.42bc	12.21 ± 0.66b
Combinations (SF):						
S1F0	3.30 ± 0.00abc	5.25 ± 0.07e	8.00 ± 0.28cde	9.10 ± 0.42cdef	10.60 ± 0.42abc	11.65 ± 0.64cde
S1F1	3.20 ± 0.14abc	5.45 ± 0.21cde	8.95 ± 0.49a	10.25 ± 1.06a	11.15 ± 0.49ab	12.65 ± 0.49ab
S1F2	3.45 ± 0.21ab	5.40 ± 0.14cde	8.40 ± 0.28b	10.20 ± 0.14ab	11.15 ± 0.64ab	12.40 ± 0.57abc
S1F3	3.20 ± 0.42abc	5.25 ± 0.21e	8.10 ± 0.42cde	9.50 ± 0.28abcde	11.00 ± 0.14ab	12.40 ± 0.57abc
S1F4	3.15 ± 0.21abc	5.30± 0.28de	8.15 ± 0.35bcd	9.35 ± 0.64cdef	11.05 ± 0.49ab	12.10 ± 0.28bcd
S2F0	3.20 ± 0.28abc	5.70 ± 0.14bcde	7.80 ± 0.00efg	8.75 ± 0.21ef	9.95 ± 0.07e	11.15 ± 0.07e
S2F1	3.30 ± 0.14abc	6.10 ± 0.42ab	8.15 ± 0.21bcd	9.45 ± 0.07bcde	10.05 ± 0.07de	11.50 ± 0.14de
S2F2	3.15 ± 0.07abc	5.85 ± 0.21abcd	7.90 ± 0.00def	9.70 ± 0.85abcd	11.05 ± 0.78ab	12.25 ± 1.06bcd
S2F3	3.15 ± 0.21abc	5.65 ± 0.07bcde	8.05 ± 0.07cde	9.50 ± 0.28abcde	10.85 ± 0.07abc	12.10 ± 0.14bcd
S2F4	3.30 ± 0.14abc	5.60 ± 0.14bcde	8.10 ± 0.00cde	9.60 ± 0.57abcd	10.55 ± 0.21bcd	11.50 ± 0.42de
S3F0	3.25 ± 0.49abc	5.95 ± 0.49abc	7.60 ± 0.14g	8.60 ± 0.14f	9.80 ± 0.28e	11.30 ± 0.28e
S3F1	3.15 ± 0.07abc	6.10 ± 0.28ab	8.00 ± 0.28cde	9.00 ± 0.00def	10.15 ± 0.07de	12.20 ± 0.14bcd
S3F2	3.40 ± 0.14ab	5.75 ± 0.35bcde	8.00 ± 0.14cde	9.20 ± 0.00cdef	10.55 ± 0.07bcd	12.25 ± 0.35bcd
S3F3	3.35 ± 0.07abc	5.95 ± 0.21abc	8.05 ± 0.07cde	9.25 ± 0.07cdef	10.25 ± 0.07de	12.20 ± 0.14bcd
S3F4	3.55 ± 0.07a	6.35 ± 0.07a	7.90 ± 0.14def	9.30 ± 0.00cdef	10.35 ± 0.21cde	12.15 ± 0.07bcd
S4F0	3.15 ± 0.07abc	5.90 ± 0.14abc	7.55 ± 0.07g	9.10 ± 0.00cdef	10.55 ± 0.21bcd	11.65 ± 0.49cde
S4F1	2.95 ± 0.07bc	5.85 ± 0.21abcd	7.65 ± 0.07fg	9.25 ± 0.07cdef	10.85 ± 0.07abc	12.50 ± 0.28ab
S4F2	2.95 ± 0.07bc	5.80 ± 0.28abcde	8.00 ± 0.14cde	9.45 ± 0.07bcde	11.00 ± 0.14ab	12.65 ± 0.07ab
S4F3	2.85 ± 0.07c	5.75 ± 0.07bcde	8.05 ± 0.21cde	9.80 ± 0.14abcd	11.40 ± 0.14a	12.65 ± 0.64ab
S4F4	3.05 ± 0.21abc	5.85 ± 0.07abcd	8.25 ± 0.07bc	9.90 ± 0.14abc	11.25 ± 0.21a	13.10 ± 0.28a
CV (%)	6.39	4.01	1.54	3.48	2.32	2.71

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The effect of NPK compound fertilizer on the leaves number at the age of 7 DAP shows the highest leaves number at the fertilizer level of 200 kg/ha, while at the age of 14 DAP the highest leaves number at the fertilizer level of 50 kg/ha, although at the two ages it was not significantly different from all fertilization levels. At the age of 21 DAP, NPK compound fertilization shown has significant effect with the highest leaves number at the fertilizer level of 50 kg/ha and significantly different from the fertilizer level of 0 kg/ha only. While at the age of 28 DAP to 42 DAP, the effect of compound NPK fertilizer on the most leaves number was indicated by the fertilizer level of 100 kg/ha and significantly different from the fertilizer level of 0 kg/ha only, except at age of 35 DAP apart from being significantly different from the level 0 kg/ha also with a fertilizer level of 50 kg/ha. The combination of slope and compound NPK fertilizer shows a significant effect on the leaves number starting at age of 7 DAP to 42 DAP (Table 3). The combination of hilly slopes with NPK compound fertilizer of 200 kg/ha level shows the highest leaves number at the age of 7 DAP to 14 DAP and was significantly different with the combination of mountainous slopes with fertilizer levels of 50, 100 and 150 kg/ha at age of 7 DAP only, as well as a combination of flat slope and fertilizer level of 0 kg/ha to 200 kg/ha, a combination of undulating slopes with fertilizer levels of 0 kg/ha, 150 and 200 kg/ha, a combination of hilly and mountainous slopes with levels 100 kg/ha. While at the age of 21 DAP, the highest leaves number was indicated by a combination of flat slope and 50 kg/ha fertilizer level that was significantly different from all treatment combinations. The same pattern was also shown by the highest leaves number at the age of 28 DAP on a combination of flat slope and 50 kg/ha fertilizer level, but significantly different from the twelve other treatment combinations. At the age of 35 DAP, the effect of mountainous slopes with fertilizer level of 150 kga ha^{-1} combination showed the highest leaves number and was significantly different from nine other treatment combinations, whereas at age of 42 DAP the highest leaves number was indicated by a combination of mountainous slopes with a fertilizer level of 200 kg ha^{-1} and significantly different from thirteen other treatment combinations.

Effect of slopes and NPK compound fertilizer on maize yields

The effects of slopes and compound NKP fertilizers show a significant effect on all yield components (Table 4). On the flat slope (0-8%), the male flowers (42.21 DAP) and the female maize flowers (47.64 DAP) were the most significantly different from the other slopes, while on the hilly slopes (15-35%) the male flowers were the longest (45.84 DAP) and female flowers (49.31 DAP). The highest of cob weight and grain yields on the flat slope (0-8%) that it was significantly different from other slopes, except that the cob weight was not significantly different from other slopes. The highest of cob weight percentage ton grain yield was shown by mountainous slopes (>35%) and has not significantly different from flat slopes. The slope position also has a significant effect on maize yield (Changere and Lal, 1997), as the slope and organic fertilizer have a significant and very significant effect on potato yield (Wati et al., 2014). The 10-22% lower content of organic matter, nitrogen, and phosphorus on the lower middle slope is associated with a decrease in maize yield of 27% compared to the position of the upper middle slope (Wezel et al., 2002).

The effect of NPK compound fertilizer on the age of male and female maize flowers was the fastest out (44.87 DAP and 48.22 DAP respectively) and the highest cob weight was shown by the fertilizer level of 100 kg/ha which was significantly different with the level of fertilizer 0 kg/ha only. While the highest of grain yields hass shown by the fertilizer level of 200 kg/ha but not significantly different from the fertilizer level of 100 kg/ha, whereas the highest of cob weight percentage to grain yield was indicated by the level of 50 kg/ha and significantly different with the level of 0 kg/ha and 200 kg/ha only. The NPK fertilization has a significant effect on maize yield parameters (Achiri et al., 2017). Flowering time can often be accelerated 3-10 days by application of NPK fertilizer (Gumeleng, 2003). Female maize flowering were most quickly obtained at the fertilizer level of 250 kg/ha N, 100 kg/ha P and 75 kg/ha K whereas the latest were obtained at 0 kg/ha level (Nurdin et al., 2009). Phosphor is able to increase the photosynthesis process which will further influence the increase in dry weight of plants (Minardi, 2002).

The combination of slope and NPK compound fertilizer shows a significant effect on all yield components (Table 4). The combination of flat slope with NPK compound fertilizer level of 100 kg/ha shows the age of male and female maize flowering fastest and has significantly different from the ten slope combinations and fertilizer level at age of male maize flowering, and significantly different from the eight slope combinations and other fertilizer levels at age of female maize flowering. Meanwhile, the highest of cob weight was shown by a combination of hilly slopes and fertilizer level of 100 kg/ha which was significantly different from four other treatment combinations only. The highest of grain yiled was shown by the combination of flat slope and fertilizer level of 200 kg/ha, but it was significantly different from only eight other treatment combinations. Whereas the highest of cob weight percentage to grain yiled was shown by the combination of mountainous slopes with a fertilizer level of 100 kga ha^{-1} and significantly different from five other treatment combinations only. The best combination of slope and NPK compound fertilizer on maize yield parameters was flat slope with fertilizer level of 100 kg/ha. This was in line with the report of Ngosong et al., (2019) that N fertilizing between 50 and 100 kg N ha^{-1} was optimal for maize production in Cameroon's volcanic soil.

Table 4-The average of component yield of maize local of Motoro Kiki varietis due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia.

Treatments	Male Flowering Age (DAP)	Female Flowering Age (DAP)	Cob Weight (ton/ha)	Grain Yields (ton/ha)	Percentage of Cob Weight to Grain Yields (%)
Slopes (S):					
S1 (0 – 8%)	44.21 ± 0.84a	47.64 ± 0.70a	1.78 ± 0.27ns	3.06 ± 0.25c	20.43 ± 2.39a
S2 (8 – 15%)	45.53 ± 0.49b	48.92 ± 0.70b	1.51 ± 0.37	2.48 ± 0.37ab	22.49 ± 2.93ab
S3 (15 – 35%)	45.84 ± 0.54b	49.31 ± 0.74b	1.70 ± 0.31	2.56 ± 0.47b	24.27 ± 3.37b
S4 (>35%)	45.53 ± 0.77b	48.82 ± 0.86b	1.55 ± 0.29	2.18 ± 0.33a	25.31 ± 4.14b
NPK Compound (F):					
F0 (0 kg/ha)	45.92 ± 1.17b	49.57 ± 1.24a	1.19 ± 0.24a	2.15 ± 0.46a	20.36 ± 2.20a
F1 (50 kg/ha)	45.01 ± 1.01ab	48.42 ± 0.85b	1.65 ± 0.31b	2.41 ± 0.49a	26.37 ± 3.77b
F2 (100 kg/ha)	44.87 ± 1.14a	48.22 ± 1.15b	1.81 ± 0.26b	2.87 ± 0.50bc	23.03 ± 5.23ab
F3 (150 kg/ha)	45.25 ± 0.57ab	48.59 ± 0.58b	1.74 ± 0.18b	2.49 ± 0.21ab	24.19 ± 1.49ab
F4 (200 kg/ha)	45.34 ± 0.43ab	48.57 ± 0.49b	1.78 ± 0.12b	2.93 ± 0.34c	21.66 ± 1.62a
Combinations (SF):					
S1F0	44.25 ± 1.63bcd	47.75 ± 1.81bcd	1.48 ± 0.42abcde	2.80 ± 0.67abcd	19.71 ± 0.85cde
S1F1	43.50 ± 0.28cd	47.17 ± 0.28cd	2.08 ± 0.21ab	3.23 ± 0.42ab	21.21 ± 3.68abcde
S1F2	43.35 ± 0.12d	46.80 ± 0.05d	1.49 ± 0.68abcde	3.20 ± 0.18ab	16.94 ± 7.83e
S1F3	44.52 ± 1.06bcd	47.86 ± 0.94bcd	1.87 ± 0.32abc	2.78 ± 0.06abcd	23.50 ± 3.25abcde
S1F4	45.42 ± 0.49abcd	48.61 ± 0.54abcd	1.95 ± 0.03abc	3.30 ± 0.11a	20.77 ± 1.29abcde
S2F0	45.98 ± 1.15ab	49.85 ± 1.01ab	0.92 ± 0.13e	2.04 ± 0.42de	18.08 ± 5.14de
S2F1	45.67 ± 0.71ab	48.91 ± 0.68abc	1.35 ± 0.25bcde	2.18 ± 0.67cde	25.93 ± 1.17abcde
S2F2	44.71 ± 0.68abcd	47.90 ± 0.61bcd	1.77 ± 0.05abcd	2.91 ± 0.47abcd	23.06 ± 5.15abcde
S2F3	45.48 ± 0.45abc	48.83 ± 0.33abcd	1.76 ± 0.44abcd	2.48 ± 1.03abcde	23.83 ± 5.83abcde
S2F4	45.80 ± 0.90ab	49.08 ± 0.82abc	1.73 ± 0.47abcd	2.79 ± 0.45abcd	21.58 ± 0.97abcde
S3F0	46.65 ± 0.26a	50.46 ± 0.38a	1.28 ± 0.10cde	1.99 ± 0.24de	23.33 ± 1.86abcde
S3F1	45.30 ± 1.79abcd	48.65 ± 1.72abcd	1.59 ± 0.14abcde	2.19 ± 0.44cde	28.87 ± 3.52abc
S3F2	46.00 ± 0.57ab	49.51 ± 0.73ab	2.13 ± 0.02a	3.22 ± 0.39ab	22.42 ± 2.67abcde
S3F3	45.86 ± 0.94ab	49.23 ± 0.94abc	1.83 ± 0.01abcd	2.30 ± 0.34bcde	26.38 ± 3.49abcd
S3F4	45.38 ± 0.07abcd	48.70 ± 0.00abcd	1.67 ± 0.17abcd	3.09 ± 0.46abc	20.32 ± 0.93bcde
S4F0	46.80 ± 0.42a	50.20 ± 0.33a	1.09 ± 0.38de	1.76 ± 0.46e	20.30 ± 0.78bcde
S4F1	45.55 ± 0.49abc	48.95 ± 0.26abc	1.57 ± 0.27abcde	2.05 ± 0.36de	29.48 ± 0.81ab
S4F2	45.43 ± 0.52abc	48.65 ± 0.45abcd	1.83± 0.09abcd	2.16 ± 0.10cde	29.71 ± 3.46a
S4F3	45.11 ± 0.68abcd	48.41 ± 0.59abcd	1.48 ± 0.12abcde	2.38 ± 0.23abcde	23.08 ± 1.32abcde
S4F4	44.75 ± 1.58abcd	47.90 ± 1.84bcd	1.77 ± 0.07abcd	2.53 ± 0.39abcde	23.96 ± 3.55abcde
CV (%)	1.88	1.77	18.54	18.53	16.34

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

Relative agronomic and economic fertilization effectiveness

The highest of relative agronomic effectiveness (RAE) values, the ratio of economic fertilization effectiveness (EFE) with subsidized fertilizer and non-subsidized was shown by flat slopes (0-8%) which differ significantly by undulating slopes (8-15%) and mountainous slopes (>35%) on RAE, significantly different from all slopes in the EFE subsidized and non-subsidized ratio (Table 5), in other to the distribution was obtained following the RAE pattern S1> S3> S2> S4. Provision of standard or recommended of NPK Fertilizers (300 kg/ha NPK+250 kg/ha Urea) shows a higher RAE value (100) than other fertilizer doses to maize plants (Kasno, 2010; Wijaya et al., 2015; Erselia et al., 2017; Subandi et al., 2017), in sugarcane (Zulkarnain et al., 2017). Furthermore, the highest of the RAE value, EFE subsidized and non-subsidized ratio with NPK compound fertilization was shown by fertilizer level of 200 kg/ha which was not significantly different with fertilizer level of 50 kg/ha and 100 kg/ha at RAE, and has not significantly different only with the level of 100 kg/ha in the EFE subsidized and non-subsidized ratio, so as the distribution was obtained following the pattern F4> F2> F3> F1> F0.

Table 5-Relative agronomic effectiveness (RAE) and economic fertilizer effectiveness (EFE) of maize yields with NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Grain Yields (ton/ha)	RAE (%)	Ratio of EFE (Subsidized Fertilizer)	Ratio of EFE (Non-Subsidized Fertilizer)
Slopes (S):				
S1 (0 – 8%)	3.06 ± 0.25c	131.98 ± 127.63a	4.66 ± 0.38a	1.34 ± 0.11a
S2 (8 – 15%)	2.48 ± 0.37ab	45.77 ± 38.99b	3.77 ± 0.57bc	1.08 ± 0.16bc
S3 (15 – 35%)	2.56 ± 0.47b	56.24 ± 55.19ab	3.89 ± 0.85b	1.12 ± 0.24b
S4 (>35%)	2.18 ± 0.33a	33.55 ± 24.19b	3.31 ± 0.46c	0.95 ± 0.13c
NPK Compound (F):				
F0 (0 kg/ha)	2.15 ± 0.46a	0.00 ± 0.00c	3.26 ± 0.69c	0.94 ± 0.20c
F1 (50 kg/ha)	2.41 ± 0.49a	68.50 ± 98.78abc	3.66 ± 0.84c	1.05 ± 0.24c
F2 (100 kg/ha)	2.87 ± 0.50bc	111.47 ± 70.62ab	4.36 ± 0.75ab	1.26 ± 0.22ab
F3 (150 kg/ha)	2.49 ± 0.21ab	28.69 ± 28.59bc	3.79 ± 0.32bc	1.09 ± 0.09bc
F4 (200 kg/ha)	2.93 ± 0.34c	125.77 ± 87.65a	4.45 ± 0.51a	1.28 ± 0.15a
Combinations (SF):				
S1F0	2.80 ± 0.67abcd	0.00 ± 338.69c	4.26 ± 1.01abcd	1.23 ± 0.29abcd
S1F1	3.23 ± 0.42ab	216.57 ± 215.72ab	4.91 ± 0.65ab	1.41 ± 0.19a
S1F2	3.20 ± 0.18ab	201.63 ± 93.48abc	4.87 ± 0.28ab	1.40 ± 0.08ab
S1F3	2.78 ± 0.06abcd	-12.33 ± 31.98c	4.23 ± 0.10abcd	1.22 ± 0.03abcd
S1F4	3.30 ± 0.11a	254.05 ± 58.19a	5.02 ± 0.17a	1.44 ± 0.05a
S2F0	2.04 ± 0.42de	0.00 ± 44.09c	3.10 ± 0.64de	0.89 ± 0.18de
S2F1	2.18 ± 0.67cde	14.41 ± 69.87bc	3.31 ± 1.02cde	0.95 ± 0.29cde
S2F2	2.91 ± 0.47abcd	90.14 ± 49.05abc	4.42 ± 0.72abcd	1.27 ± 0.21abcd
S2F3	2.48 ± 1.03abcde	46.41 ± 107.49abc	3.78 ± 1.57abcde	1.09 ± 0.45abcde
S2F4	2.79 ± 0.45abcd	77.91 ± 46.97abc	4.24 ± 0.68abcd	1.22 ± 0.20abcd
S3F0	1.99 ± 0.24de	0.00 ± 23.75c	3.03 ± 0.36de	0.87 ± 0.10de
S3F1	2.19 ± 0.44cde	19.93 ± 44.03bc	3.33 ± 0.68cde	0.96 ± 0.19cde
S3F2	3.22 ± 0.39ab	121.84 ± 38.66abc	4.90 ± 0.59ab	1.41 ± 0.17ab
S3F3	2.30 ± 0.34bcde	30.75 ± 33.48bc	3.50 ± 0.51bcde	1.01 ± 0.15bcde
S3F4	3.09 ± 0.46abc	108.67 ± 45.97abc	4.69 ± 0.71abc	1.35 ± 0.20abc
S4F0	1.76 ± 0.46e	0.00 ± 37.02c	2.67 ± 0.70e	0.77 ± 0.20e
S4F1	2.05 ± 0.36de	23.07 ± 29.31bc	3.11 ± 0.55de	0.89 ± 0.16de
S4F2	2.16 ± 0.10cde	32.28 ± 8.21bc	3.28 ± 0.15cde	0.94 ± 0.04cde
S4F3	2.38 ± 0.23abcde	49.93 ± 18.84abc	3.62 ± 0.36abcde	1.04 ± 0.10abcde
S4F4	2.53 ± 0.39abcde	62.46 ± 31.35abc	3.85 ± 0.59abcde	1.11 ± 0.17abcde
CV (%)	18.53	160.21	18.52	18.57

Mean ± standard deviation, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The highest of RAE, the EFE subsidized and non-subsidized ratio in the combination of slope and NPK compound fertilization has shown by the combination of flat slope with fertilizer level 200 kg/ha which was significantly different from the ten other treatment combinations at RAE value and significantly different from eight other treatment combinations at the EFE subsidized and non-subsidized ratio (Table 5). While the lowest RAE value was indicated by the combination of flat slope with fertilizer level of 150 kg/ha which was significantly different from the combination of flat slope and fertilizer level of 50 kg/ha only, the EFE subsidized and non-subsidized ratio was indicated by the combination of mountainous slopes with fertilizer level of 0 kg/ha and significantly different from ten other treatment combinations. Thus, the combination of a flat slope with a fertilizer level of 100 kg/ha is the best combination that can be applied by maize farmers. This was in line with the report of Wijaya et al. (2015) that fertilizing urea at 100 kg/ha, SP-36 at 200 kg/ha and KCl at 100 kg/ha showed the highest EFE ratio in both subsidized and non-subsidized fertilizers. However, if farmers will continue to maize cultivating on sloping land, it was recommended to arrive at hilly slopes (15-35%) with fertilizer levels of 100 kg/ha only.

CONCLUSION

The slope and NPK compound fertilization can increase the maize growths. The best combination in increasing plant height and leaves number was the combination of flat slope and fertilizer level of 100 kg/ha. The slope and NPK compound fertilization can increase the maize yields. The best combination in accelerating the age of male and female maize flowering, increasing the grain yield was the combination of flat slope and fertilizer level of 100 kg/ha. While on cob weight was combination of hilly slope and fertilizer level of 100 kg/ha, whereas on the percentage of cob weight to grain yield was a combination of mountainous slope and fertilizer level of 100 kg/ha. The slope and NPK compound fertilization can increase the RAE percentage, the EFE subsidized and non-subsidized ratio. The best combination of flat slopes and compound NPK fertilization level of 200 kg/ha has significantly increase the percentage of RAE, the EFE subsidized and non-subsidized ratio, but relatively equal to the the level of 100 kg/ha. If farmers will continue to maize cultivating on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg/ha only.

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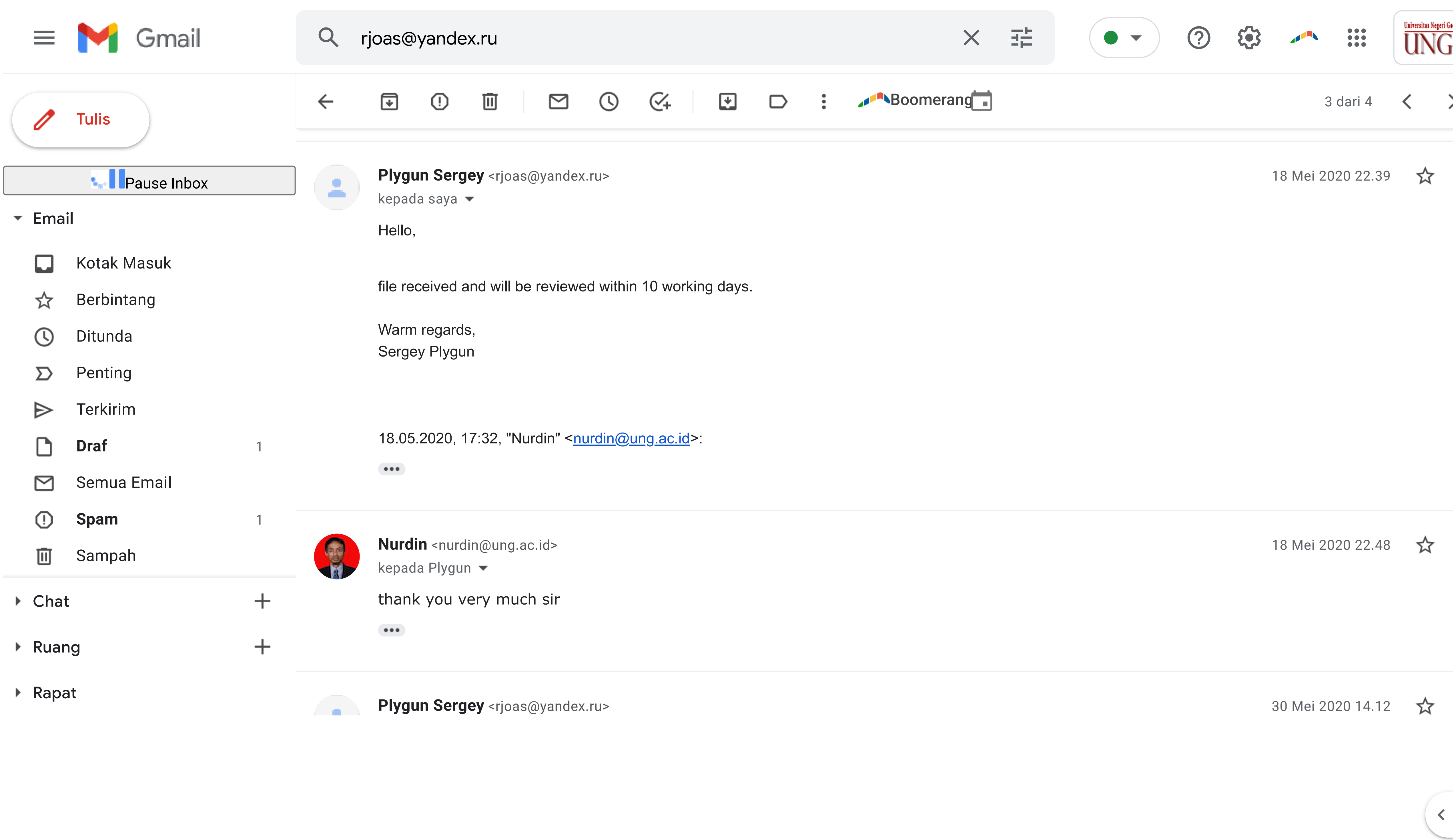
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EFFECT OF SLOPES AND COMPOUND NPK FERTILIZER ON GROWTH AND YIELD OF MAIZE LOCAL VARIETIES, RELATIVE AGRONOMIC AND ECONOMIC FERTILIZER EFFECTIVENESS TO INCEPTISOL BUMELA, INDONESIA

Nurdin*
Doctorate Program of Agriculture Science, Brawijaya University, Veteran street 65145 Malang, Indonesia.

Mochtar Lutfi Rayes, Soemarno, Sudarto
Department of Soil Science, Faculty Agriculture, Brawijaya University, Veteran Street 65145 Malang, Indonesia.

Nikmah Musa, Muhajir Dunggio
Department of Agrotechnology, Faculty of Agriculture, Gorontalo State University, Genderal Sudirman Street 96122 Gorontalo, Indonesia

*Email: nurdin@ung.ac.id

ABSTRACT
Maize cultivation has been carried out on the mountainous slopes with high fertilizer inputs, but maize productivity is still low. This study investigates the effect of slope and NPK compound fertilization as well as the best combination of growth and yield of local maize, relative agronomic effectivness (RAE) percentages and economik fertilizer effectiveness (EFE) ratio in Inceptisol Bumela, Indonesia. Slope variations (0-8, 8-15, 15-35, >35%) are combined with compound NPK fertilizer levels (0, 50, 100, 150, 200 kg/ha) with split plot design. Growth data was recorded for changes in plant height and leaves number from 7 DAP to 42 DAP, while yield and yield components are recorded at harvest. The results showed that slope and NPK compound fertilization can increase the growth and yield of maize plants. The combination of flat slopes and fertilizer level of 100 kg/ha was the best combination in increasing plant height and the leaves number, accelerate the age of male and female flowering flowers, cob weight, grain yield and percentage of cob weight to grain yields. This combination was also able to increase the percentage of RAE, the ratio of EFE subsidized and non-subsidized. If farmers will continue to cultivate maize on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg/ha only.

KEY WORDS: Slope, fertilizer, NPK compound, growth, yield, maize.

Maize is an excellent commodity in Gorontalo province of Indonesia. Gorontalo Province maize production until 2018 has reached 1.7 million tons or increased by 9.3% from the previous year with a productivity of 5.0 ton/ha (BPS, 2019) which places Gorontalo Province as one of the largest maize producers in Indonesia (Yunus et al., 2018). Maize was cultivated from generation to generation by local farmers (Ardiani, 2009; Fadhilah, 2013) using maize local varieties. However, since 2002 through the agropolitan programs with maize commodity (Jocom et al., 2009; Grace, 2010), the use of local varieties has changed to maize hybrid and composite varieties, so as the maize local variety were rarely planted and threatened with extinction.

One of Gorontalo's local germplasm was the Motoro Kiki variety (Zubachtirodin and Kasim, 2012). Motoro Kiki is a Gorontalo maize local variety (Yasin et al., 2007) that aged 70-80 day after planting (DAP), yield potential was 3 ton/ha of grain yield, resistant to downy mildew and leaf rust, and was well planted in the lowlands to the highlands (IAARD, 2009). Maize local has better growth than hybrid and maize composite, but the yield component shows the opposite patterns (Kaihatu and Pesireron, 2016).

Maize cultivation in Gorontalo Province region was very massive and has carried out on upland with a slope of 0% (flats) to mountainous land (slope >35%) which was vulnerable to land degradation. In fact, soil erosion that occurred from the Agropolitan maize planting area reported by Husain et al., (2004) as many as 1.396 ton/ha/year. If this condition was left, it will threaten the sustainability of maize farming. Upland for maize cultivation in Bumela Village was generally on Inceptisol (Indonesian Soil and Agroclimate Research Center Team, 1995). Inceptisol was a relatively young soil and its development was a level above of the Entisols (Rachim, 2007), including having a cambic horizons with a percentage of Na can be exchanged by 15% or more (Soil Survey Staff, 2014). Inceptisol has the potential to be developed (Nursyamsi et al., 2002; Hermawan et al., 2018) because it covers 70 million hectare in Indonesia (Kasno, 2009; Muyassir et al., 2012; Hermawan et al., 2018). However, these soils generally have low soil fertility and organic matter content (Abdurachman et al., 2008; Arviandi et al., 2015). Meanwhile, the high intensity of tillage for maize cultivation has led to a decrease in soil fertility (Lorenz et al., 2000; Husain et al., 2002; Pomalingo and Husain, 2003), so as the maize productivity is low, although fertilizer application exceeds recommendations.

A literature study on the results of the effect of slope and compound NPK fertilization combined with the specific growth and yield of maize local variety has not been found. While information on the performance of growth and yield of maize local on various slopes combined with the level of NPK compound fertilization is very important for farmer and policy maker, especially in the Gorontalo Province. In fact, maize farmers continue to cultivate on sloping land of >25% with less fertilizer input or exceed the recommended fertilizer levels, so this research was important to done. This study aims to investigate the growth and yield of maize local variety of Motoro Kiki, the relative agronomic effectiveness (RAE) and economic fertilization effectiveness (EFE) on various slopes and NPK compound fertilization to Inceptisol Bumela, Indonesia.

MATERIAL AND METHODS

Site study area

The study was conducted to four months (December 2019 to March 2020) on the toposequence of farmers maize land in Bumela Village, Bilato District, Gorontalo Regency, Gorontalo Province, Indonesia. Specifically geographical, the experimental field was rectangular located at $0^0$36'11.98"-$0^0$36'11.46" N and $122^0$40'01.33"-$122^0$40'02.49" E at an altitude of 314 m asl, and $0^0$36'08.39"-$0^0$36'08.11" N and $122^0$40'00.31"-$122^0$40'01.45" E with an altitude of 339 m asl.

Table 1-Some soil physico-chemical properties were selected at a depth of 0-30 cm

No	Soil properties	Value	Criterion*
1.	Textures:		
a.	Sand (%)	62.00	Sandy clay
b.	Silt (%)	21,50	
c.	Clay (%)	16.60	
2.	pH (H2O	5,65	Rather sour
3.	Soil organik carbon (%)	0.67	Very low
4.	Total nitrogen (%)	0,07	Very low
5.	P-Bray 1 available (mg/ka)	4.02	Low
6.	Cations exchangeable:		
a.	K^+	0.29	Low
b.	Na^+	2.16	Low
c.	Ca^{2+}	3.86	Low
d.	Mg^+	0,38	Low
7.	Cation exchange capacity (cmol/kg)	8.94	Low
8.	Base saturation (%)	79,88	High
9.	Na saturation (%)	24,27	High

**Eviyati and Soleman (2009).*

This soil is very dark gray brown (10YR 3/2), granular of soil structure and sandy clay of texture, cation exchange capacit of 8.94 cmol/kg and base saturation 79.88%, Na saturation of 24.17% (Table 1). Annual average rainfall of 1,245.90 mm with annual average temperature of 28.02ºC and potential evapotranspiration of 152.95 mm, so the soil moisture regime was Ustic (106 dry days without humid days) and the soil temperature regime was Isohiperthermik. Based on the soil morphology, physicochemical properties and other properties soils, the soil in the experimental field was classified as Oxic Humustepts (Soil Survey Staff, 2014).

Research material

The compound fertilizer used was NPK Phonska fertilizer with nutrient content (%) of 15-15-15 and Gorontalo maize local was used Motoro Kiki variety. The land was used upland owned by maize farmers with Inceptisol (Oxic Humustepts) soil type. This upland was used starting from flate (0-8%), unduleting (8-15%), hills (15-35%) and mountainous land (> 35%) on one toposequency.

Field experimentals

The field experimental are designed following a split plot design. Four slope treatments were slope of 0-8% (S1), 8-15% (S2), 15-35% (S3) and slope >35% (S4) as the main plots. While the five NPK compound fertilizer treatments, namely 0 kg/ha (F0), 50 kg/ha (F1), 100 kg/ha (F2), 150 kg/ha (F3), and the level of 200 kg/ha (F4) as subplots. Each treatment was repeated three replication, so as 60 treatment plot combinations were obtained. The treatment plot was made 2 x 2 m by smoothing the soil evenly with hoe and shovel. The distance between plots was made 1 m to facilitate accessibility to and from the treatment plot.

Maize was planted with a distance of 20 x 40 cm in the planting hole of 2 maize seeds (December 26, 2019), so as to get 50 plant populations per plot. At the maize age of 7 day after planting (DAP), weed cleansing and thinning into 1 plant per holes. The first fertilization was done (1/2 level of fertilization per treatment) and plant embellishment was followed. Weed cleansing and embellishment was done when growing weeds manually with a hoe. At the maize age of 30 DAP, the second fertilization (the remaining 1/2 level of fertilization per treatment) was continued with plant embellishment. Maintenance continues until the harvest stage. Maize harvesting was done when the physical condition of the maize was dry and yellows (26 March 2020) or ± 90 DAP.

Observation of maize growth variables, including plant height (cm) and leaves number was carried out from plants aged 7 DAP to male flowers (± 42 DAP) on ten selected plants per plot. While the maize yield variables, including age of male and female flowering (DAP) were observed when maize flowers first appeared, the cob weight (ton/ha) was weighed after the maize seeds were separated from the cob, the grain yield (ton/ha) was weighed after the maize seeds were dried under 5 days sun exposure (± 15% moisture content) and the percentage of cob weight to grain yields (%).

Data analysis

NPK compound fertilizer applied, either singly or in combination was tested by relative agronomic effectiveness or RAE (Mackay et al., 1984; Chien, 1996) with the following equation:

$$RAE = \frac{Yt - Yo}{Ys - Yo} x\, 100$$

Where: Yt = maize yield on the tested fertilizer (ton/ha), Ys = maize yield standard (ton/ha), and Yo = maize yield on the control treatment (ton/ha). The greater the percentage of RAE, the better the effectiveness of fertilizer relative to agronomic traits. Meanwhile, to find out the fertilizer used has a good economic value, an economic fertilizing effectiveness (EFE) was carried out with the following equation:

$$Ratio\ EFE = \frac{P\ x\ Q}{C}$$

Where: P = price of maize per kg (IDR/Kg), Q = total yield (kg/ha), and C = price of fertilizer (IDR/Ha). If the EFE ratio was >1, the fertilizer tested has good economic value (Saeri and Suwono, 2012; Wijaya et al., 2015).

The price of maize per kg in the study area was IDR 3.500. While the price of Phonska compound NPK fertilizer consists of two, namely NPK Phonska was subsidized by the government at a price of IDR 2.300 and non-subsidized at a price of IDR 8.000. The two forms of NPK fertilizer were used as a comparison material as well as consideration in making the best agronomic and economical NPK compound fertilizer selection decisions. All data obtained were analyzed with ANOVA of split plot design divided into patterns 4^5. If there was a treatment that has a significant effect, then it was continued with the Duncan Multiple Range Test (DMRT) at the test level P >0,05 with the tools of the Statistical Analysis System (SAS) program.

RESULT AND DISCUSSION

Effect of slope and NPK compound fertilizer on maize growth

Slopes and NPK compound fertilization showed has significant effect on the plant height at the age of 14, 21, 28, 35, and 42 DAP, except at the age of 7 DAP in all treatments and at the age of 14 DAP in the treatment of compound NPK fertilizer that has not significantly affected (Tabel 2).

Table 2-The average of plant height of maize local of Motoro Kiki varieti due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Plant Heigh (cm)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	16.37 ± 0.40ns	33.28 ± 1.89ab	79.70 ± 4.31c	95.92 ± 6.48b	137.33 ± 4.49c	180.87 ± 10.48b
S2 (8 – 15%)	16.06 ± 0.38	34.97 ± 1.87b	69.99 ± 4.32b	83.90 ± 8.08a	120.67 ± 11.47ab	160.46 ± 13.22a
S3 (15 – 35%)	16.13 ± 0.40	32.36 ± 0.87a	63.41 ± 2.89a	89.26 ± 3.13a	113.94 ± 3.97a	159.33 ± 8.48a
S4 (>35%)	16.05 ± 0.62	33.02 ± 1.23ab	68.77 ± 2.93b	99.01 ± 5.19b	127.07 ± 7.89b	160.52 ± 9.95a
NPK Compound (F):						
F0 (0 kg/ha)	16.45 ± 0.48ns	34.00 ± 0.65ns	69.80 ± 4.68ab	88.57 ± 11.43a	117.13 ± 12.57a	150.65 ± 10.18a
F1 (50 kg/ha)	15.97 ± 0.17	33.31 ± 2.09	70.32 ± 8.59ab	92.70 ± 6.39ab	124.86 ± 10.99abc	164.78 ± 15.32b
F2 (100 kg/ha)	16.33 ± 0.39	34.33 ± 2.88	72.38 ± 9.92b	96.53 ± 5.90b	131.45 ± 12.71c	173.05 ± 14.53b
F3 (150 kg/ha)	15.97 ± 0.66	32.22 ± 0.71	66.72 ± 5.81a	88.65 ± 7.05a	121.95 ± 8.25ab	168.51 ± 7.38b
F4 (200 kg/ha)	16.02 ± 0.36	33.16 ± 1.20	73.10 ± 6.42b	93.65 ± 10.16ab	128.36 ± 11.33bc	169.47 ± 11.83b
Combinations (SF):						
S1F0	16.35 ± 0.49ns	33.55 ± 3.18abcd	76.55 ± 8.70abc	100.00 ± 17.11abc	134.50 ± 12.45abcd	163.95 ± 12.52cdef
S1F1	15.85 ± 0.92	32.75 ± 0.35abcd	81.75 ± 1.48ab	98.90 ± 1.84abcd	139.80 ± 5.66ab	187.65 ± 9.69ab
S1F2	16.50 ± 0.42	36.40 ± 4.81ab	84.45 ± 6.29a	102.70 ± 3.39ab	143.50 ± 7.07a	190.60 ± 6.93a
S1F3	16.95 ± 3.89	31.65 ± 5.30bcd	73.95 ± 13.79abcd	89.55 ± 18.60bcde	132.00 ± 4.38abcde	178.75 ± 13.22abcd
S1F4	16.20 ± 1.13	32.05 ± 2.90bcd	81.80 ± 4.53ab	88.45 ± 1.63bcde	136.85 ± 4.31abc	183.40 ± 3.54abc
S2F0	16.20 ± 0.00	34.40 ± 5.37abcd	67.45 ± 8.56cdef	73.30 ± 10.89f	107.30 ± 13.01h	139.20 ± 13.15g
S2F1	16.20 ± 1.13	36.35 ± 2.90abc	71.50 ± 3.54bcdef	85.10 ± 3.54cdef	118.10 ± 2.97defgh	158.15 ± 2.76efg
S2F2	16.55 ± 0.21	37.20 ± 3.68a	76.15 ± 1.63abc	95.70 ± 1.27abcde	138.95 ± 16.33ab	174.45 ± 16.19abcde
S2F3	15.60 ± 1.56	32.40 ± 0.42abcd	64.70 ± 1.98cdef	81.10 ± 1.41ef	120.90 ± 7.64cdefgh	165.55 ± 2.05cdef
S2F4	15.75 ± 0.21	34.50 ± 1.13abcd	70.15 ± 6.01bcdef	84.30 ± 3.82def	118.10 ± 10.89defgh	164.95 ± 2.90cdef
S3F0	16.10 ± 0.42	33.35 ± 2.76abcd	66.05 ± 1.48cdef	87.30 ± 0.99cdef	108.50 ± 1.27gh	148.95 ± 4.60fg
S3F1	16.00 ± 0.00	31.55 ± 2.05cd	61.80 ± 10.18ef	89.85 ± 3.89bcde	115.30 ± 3.68efgh	158.40 ± 10.75efg
S3F2	16.55 ± 0.78	31.50 ± 0.99d	62.20 ± 3.54def	88.80 ± 2.97bcde	114.90 ± 2.69efgh	172.05 ± 8.70abcde
S3F3	15.55 ± 1.06	33.15 ± 1.06abcd	60.15 ± 3.32f	86.10 ± 0.28cdef	111.90 ± 0.57fgh	161.45 ± 4.88def
S3F4	16.45 ± 1.06	32.25 ± 2.90bcd	66.85 ± 1.63cdef	94.25 ± 2.76abcde	119.10 ± 0.99defgh	155.80 ± 0.85efg
S4F0	17.15 ± 0.78	34.70 ± 0.57abcd	69.15 ± 3.04cdef	93.70 ± 5.66abcde	118.25 ± 14.07defgh	150.50 ± 7.50fg
S4F1	15.85 ± 0.35	32.60 ± 1.13abcd	66.25 ± 2.62cdef	96.95 ± 5.87abcd	126.25 ± 12.52abcdefg	154.95 ± 1.77efg
S4F2	15.75 ± 0.35	32.25 ± 2.33bcd	66.75 ± 4.17cdef	98.95 ± 5.16abcd	128.45 ± 13.65abcdef	155.10 ± 11.60efg
S4F3	15.80 ± 0.28	31.70 ± 0.42bcd	68.10 ± 5.94cdef	97.85 ± 7.57abcd	123.00 ± 8.91bcdefgh	168.30 ± 7.21bcdef
S4F4	15.70 ± 0.57	33.85 ± 1.48abcd	73.60 ± 3.54abcde	107.60 ± 14.42a	139.40 ± 28.43ab	173.75 ± 27.08abcde
CV (%)	7.18	5.88	6.93	6.75	5.84	5.05

Mean ± standard deviation, DAP: day after planting, ns: not significant, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

This was be fathomed because it was not directly related to the plant physiological aspects, but directly related to soil characteristics. Slopes were closely related to the quantity of soil organic carbon, total N, and enzyme activity by changing the rate of litter

decomposition and soil microbial activity (Nahidan et al., 2015). The highest rate of plant height increase at the age of 28 DAP with an average percentage of plant height increase of 111,05% in all treatments and decreased until the age of 42 DAP. While, the highest rate of plant height increase with an average percentage of plant height increase of 70,56% was indicated by the slope 0% (flat) and NPK compound fertilizer as much as 50 kg/ha, while the rate of plant height increase was lowest with an average percentage of plant height increase of 58.12% only was shown by the slopes >35% (mountainous) and NPK compound fertilizer as much as 0 kg/ha.

Apparently, the effect of slopes began to be seen clearly in plant height from the age of 14 DAP to 42 DAP, where the flat slope had a significant effect on plant height and the peak effect of the slope was more pronounced at plant height aged of 35 and 42 DAP, followed by a undulating slope. The position of the slope has a significant effect on the maize growth (Changere and Lal, 1997). Hilly and mountainous slopes will receive more sunlight than undulating and flat slopes, so that decomposition of organic matter and nutrient cycling was better. Humidity is a basic environmental factor in a relatively dry area, so higher humidity at the shady slopes location can lead to better nutrition cycles and higher microbial community activity (Xue et al., 2018). The levels of C-organic, total N, P are available and K can be exchanged at the study site is relatively low (Table 1), so fertilizing action was needed. While the effect of NPK compound fertilizer began to be seen clearly in plant height later on from the age of 21 DAP to 42 DAP, where the fertilizing level of 100 kg/ha showed the highest plant height from the age of 28 DAP, 35 and 42 DAP, but it was not significantly different from the fertilizer level of 50 kg/ha and 200 kg/ha at the age of 21 DAP, 28, 35 and 42 DAP, except with fertilizer levels 0 kg/ha and 150 kg/ha were significantly different at the age of 28 DAP and 35 DAP. The NPK fertilization has a significant effect on the agronomic parameters of maize (Achiri et al., 2017). Nitrogen is another important soil nutrient that affects plant growth and water use efficiency (Sardans et al., 2008). The application of Phosphor fertilizer increases the efficient utilization of N fertilizer on the production of maize biomass (Mensah and Mensah, 2016). Potassium is needed for maize growth (Solihin et al., 2019).

The combination of slopes and NPK compound fertilizers began to showing a significant effect on plant height aged of 14 DAP to 42 DAP, while at age of 7 DAP had no significant effect (Table 2). The combination of flat slope (0-8%) to undulating slope (8-15%) with NPK fertilizer compound level of 100 kg/ha shows the highest plant height at the age of 21 DAP to 42 DAP. While on a combination of hilly slopes (15-35%) and mountainous slopes (35%) with all levels of fertilization was relatively varied. However, if the lands with these slopes will still be used for maize cultivation, then it will be sought only to land with hilly slopes (15-35%) combined with NPK compound fertilizer levels of 100 kg/ha because plant height reaches of 174,45 cm at age of 42 DAP. At low fertilization rates, the amount of N and K absorbed by plants increases with the amount of fertilizer applied (Niu et al., 2013). Maize plants absorb large amounts of N from the soil at V6 and maximum absorption occurs before silking (Ma' et al., 2003).

The effect of the slope on the leaves number shows the significant effect from the age of 7 DAP to 42 DAP, while the effect of compound NPK fertilization shows the significant effect later starting at age of 21 DAP to 42 DAP (Table 3). The highest rate of leaves number increasing occurred at the age of 14 DAP with an average percentage of leaves number increase of 79.70% in all treatments and decreased until the age of 42 DAP. The rate of increasing the leaves number with an average percentage leaves number increase by 38.16% was indicated by the slopes >35% (mountainous) and NPK compound fertilizer as much as 150 kg/ha, while the rate of increasing the leaves number with an average the percentage of leaves number increase was 29,94% only, as indicated by the slopes 15-35% (hilly) and NPK compound fertilizer as much as 200 kg/ha. Leaves number of maize increased significantly as the plants aged with NPK

fertilizing (Titah et al., 2016). Effect of slope on the leaves number at age of 7 DAP shows the highest leaves number on hilly slopes (15-35%) and not significantly different from flat slopes (0-8%) and undulating slopes (8-15%), but significantly different from slopes mountainous (>35%). At the age of 14 DAP, the effect of hilly slopes still shows the highest leaves number and was significantly different from flat slopes and undulating slopes, while those with mountainous slopes are not significantly different. At the age of 21 DAP and 28 DAP, the effect of flat slope has shown the highest leaves number and was significantly different from all slope classes, except at the age of 28 DAP which was only significantly different from hilly slopes. While at the age of 35 DAP and 42 DAP, the effect of mountainous slopes shows the highest leaves number and was not significantly different from flat slopes.

Table 3-The average of number leaves of maize local of Motoro Kiki variety due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Leaves Number (strands)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	3.26 ± 0.12b	5.33 ± 0.09a	8.32 ± 0.38a	9.68 ± 0.52b	10.99 ± 0.23c	12.24 ± 0.38bc
S2 (8 – 15%)	3.22 ± 0.08b	5.78 ± 0.20b	8.00 ± 0.15b	9.40 ± 0.38b	10.49 ± 0.48b	11.70 ± 0.46a
S3 (15 – 35%)	3.34 ± 0.15b	6.02 ± 0.22c	7.91 ± 0.18b	9.07 ± 0.29a	10.22 ± 0.28a	12.02 ± 0.40b
S4 (>35%)	2.99 ± 0.11a	5.83 ± 0.06bc	7.90 ± 0.29b	9.50 ± 0.34b	11.01 ± 0.33c	12.51 ± 0.53c
NPK Compound (F):						
F0 (0 kg/ha)	3.22 ± 0.06ns	5.70 ± 0.32ns	7.73 ± 0.21a	8.88 ± 0.25a	10.22 ± 0.41a	11.43 ± 0.25a
F1 (50 kg/ha)	3.15 ± 0.15	5.87 ± 0.31	8.18 ± 0.55b	9.48 ± 0.54b	10.55 ± 0.54b	12.21 ± 0.51b
F2 (100 kg/ha)	3.23 ± 0.23	5.70 ± 0.20	8.07 ± 0.22b	9.63 ± 0.43b	10.93 ± 0.27c	12.38 ± 0.19b
F3 (150 kg/ha)	3.13 ± 0.21	5.65 ± 0.29	8.06 ± 0.02b	9.51 ± 0.23b	10.87 ± 0.48c	12.33 ± 0.24b
F4 (200 kg/ha)	3.26 ± 0.22	5.77 ± 0.44	8.10 ± 0.15b	9.53 ± 0.28b	10.80 ± 0.42bc	12.21 ± 0.66b
Combinations (SF):						
S1F0	3.30 ± 0.00abc	5.25 ± 0.07e	8.00 ± 0.28cde	9.10 ± 0.42cdef	10.60 ± 0.42abc	11.65 ± 0.64cde
S1F1	3.20 ± 0.14abc	5.45 ± 0.21cde	8.95 ± 0.49a	10.25 ± 1.06a	11.15 ± 0.49ab	12.65 ± 0.49ab
S1F2	3.45 ± 0.21ab	5.40 ± 0.14cde	8.40 ± 0.28b	10.20 ± 0.14ab	11.15 ± 0.64ab	12.40 ± 0.57abc
S1F3	3.20 ± 0.42abc	5.25 ± 0.21e	8.10 ± 0.42cde	9.50 ± 0.28abcde	11.00 ± 0.14ab	12.40 ± 0.57abc
S1F4	3.15 ± 0.21abc	5.30± 0.28de	8.15 ± 0.35bcd	9.35 ± 0.64cdef	11.05 ± 0.49ab	12.10 ± 0.28bcd
S2F0	3.20 ± 0.28abc	5.70 ± 0.14bcde	7.80 ± 0.00efg	8.75 ± 0.21ef	9.95 ± 0.07e	11.15 ± 0.07e
S2F1	3.30 ± 0.14abc	6.10 ± 0.42ab	8.15 ± 0.21bcd	9.45 ± 0.07bcde	10.05 ± 0.07de	11.50 ± 0.14de
S2F2	3.15 ± 0.07abc	5.85 ± 0.21abcd	7.90 ± 0.00def	9.70 ± 0.85abcd	11.05 ± 0.78ab	12.25 ± 1.06bcd
S2F3	3.15 ± 0.21abc	5.65 ± 0.07bcde	8.05 ± 0.07cde	9.50 ± 0.28abcde	10.85 ± 0.07abc	12.10 ± 0.14bcd
S2F4	3.30 ± 0.14abc	5.60 ± 0.14bcde	8.10 ± 0.00cde	9.60 ± 0.57abcd	10.55 ± 0.21bcd	11.50 ± 0.42de
S3F0	3.25 ± 0.49abc	5.95 ± 0.49abc	7.60 ± 0.14g	8.60 ± 0.14f	9.80 ± 0.28e	11.30 ± 0.28e
S3F1	3.15 ± 0.07abc	6.10 ± 0.28ab	8.00 ± 0.28cde	9.00 ± 0.00def	10.15 ± 0.07de	12.20 ± 0.14bcd
S3F2	3.40 ± 0.14ab	5.75 ± 0.35bcde	8.00 ± 0.14cde	9.20 ± 0.00cdef	10.55 ± 0.07bcd	12.25 ± 0.35bcd
S3F3	3.35 ± 0.07abc	5.95 ± 0.21abc	8.05 ± 0.07cde	9.25 ± 0.07cdef	10.25 ± 0.07de	12.20 ± 0.14bcd
S3F4	3.55 ± 0.07a	6.35 ± 0.07a	7.90 ± 0.14def	9.30 ± 0.00cdef	10.35 ± 0.21cde	12.15 ± 0.07bcd
S4F0	3.15 ± 0.07abc	5.90 ± 0.14abc	7.55 ± 0.07g	9.10 ± 0.00cdef	10.55 ± 0.21bcd	11.65 ± 0.49cde
S4F1	2.95 ± 0.07bc	5.85 ± 0.21abcd	7.65 ± 0.07fg	9.25 ± 0.07cdef	10.85 ± 0.07abc	12.50 ± 0.28ab
S4F2	2.95 ± 0.07bc	5.80 ± 0.28abcde	8.00 ± 0.14cde	9.45 ± 0.07bcde	11.00 ± 0.14ab	12.65 ± 0.07ab
S4F3	2.85 ± 0.07c	5.75 ± 0.07bcde	8.05 ± 0.21cde	9.80 ± 0.14abcd	11.40 ± 0.14a	12.65 ± 0.64ab
S4F4	3.05 ± 0.21abc	5.85 ± 0.07abcd	8.25 ± 0.07bc	9.90 ± 0.14abc	11.25 ± 0.21a	13.10 ± 0.28a
CV (%)	6.39	4.01	1.54	3.48	2.32	2.71

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The effect of NPK compound fertilizer on the leaves number at the age of 7 DAP shows the highest leaves number at the fertilizer level of 200 kg/ha, while at the age of 14 DAP the highest leaves number at the fertilizer level of 50 kg/ha, although at the two ages it was not significantly different from all fertilization levels. At the age of 21 DAP, NPK compound fertilization shown has significant effect with the highest leaves number at the fertilizer level of 50 kg/ha and significantly different from the fertilizer level of 0 kg/ha only. While at the age of 28 DAP to 42 DAP, the effect of compound NPK fertilizer on the most leaves number was indicated by the fertilizer level of 100 kg/ha and significantly different from the fertilizer level of 0 kg/ha only, except at age of 35 DAP apart from being significantly different from the level 0 kg/ha also with a fertilizer level of 50 kg/ha. The combination of slope and compound NPK fertilizer shows a significant effect on the leaves number starting at age of 7 DAP to 42 DAP (Table 3). The combination of hilly slopes with NPK compound fertilizer of 200 kg/ha level shows the highest leaves number at the age of 7 DAP to 14 DAP and was significantly different with the combination of mountainous slopes with fertilizer levels of 50, 100 and 150 kg/ha at age of 7 DAP only, as well as a combination of flat slope and fertilizer level of 0 kg/ha to 200 kg/ha, a combination of undulating slopes with fertilizer levels of 0 kg/ha, 150 and 200 kg/ha, a combination of hilly and mountainous slopes with levels 100 kg/ha. While at the age of 21 DAP, the highest leaves number was indicated by a combination of flat slope and 50 kg/ha fertilizer level that was significantly different from all treatment combinations. The same pattern was also shown by the highest leaves number at the age of 28 DAP on a combination of flat slope and 50 kg/ha fertilizer level, but significantly different from the twelve other treatment combinations. At the age of 35 DAP, the effect of mountainous slopes with fertilizer level of 150 kga ha^{-1} combination showed the highest leaves number and was significantly different from nine other treatment combinations, whereas at age of 42 DAP the highest leaves number was indicated by a combination of mountainous slopes with a fertilizer level of 200 kg ha^{-1} and significantly different from thirteen other treatment combinations.

Effect of slopes and NPK compound fertilizer on maize yields

The effects of slopes and compound NKP fertilizers show a significant effect on all yield components (Table 4). On the flat slope (0-8%), the male flowers (42.21 DAP) and the female maize flowers (47.64 DAP) were the most significantly different from the other slopes, while on the hilly slopes (15-35%) the male flowers were the longest (45.84 DAP) and female flowers (49.31 DAP). The highest of cob weight and grain yields on the flat slope (0-8%) that it was significantly different from other slopes, except that the cob weight was not significantly different from other slopes. The highest of cob weight percentage ton grain yield was shown by mountainous slopes (>35%) and has not significantly different from flat slopes. The slope position also has a significant effect on maize yield (Changere and Lal, 1997), as the slope and organic fertilizer have a significant and very significant effect on potato yield (Wati et al., 2014). The 10-22% lower content of organic matter, nitrogen, and phosphorus on the lower middle slope is associated with a decrease in maize yield of 27% compared to the position of the upper middle slope (Wezel et al., 2002).

The effect of NPK compound fertilizer on the age of male and female maize flowers was the fastest out (44.87 DAP and 48.22 DAP respectively) and the highest cob weight was shown by the fertilizer level of 100 kg/ha which was significantly different with the level of fertilizer 0 kg/ha only. While the highest of grain yields hass shown by the fertilizer level of 200 kg/ha but not significantly different from the fertilizer level of 100 kg/ha, whereas the highest of cob weight percentage to grain yield was indicated by the level of 50 kg/ha and significantly different with the level of 0 kg/ha and 200 kg/ha only. The NPK fertilization has a significant effect on maize yield parameters (Achiri et al., 2017). Flowering time can often be accelerated 3-10 days by application of NPK fertilizer (Gumeleng, 2003). Female maize flowering were most quickly obtained at the fertilizer level of 250 kg/ha N, 100 kg/ha P and 75 kg/ha K whereas the latest were obtained at 0 kg/ha level (Nurdin et al., 2009). Phosphor is able to increase the photosynthesis process which will further influence the increase in dry weight of plants (Minardi, 2002).

The combination of slope and NPK compound fertilizer shows a significant effect on all yield components (Table 4). The combination of flat slope with NPK compound fertilizer level of 100 kg/ha shows the age of male and female maize flowering fastest and has significantly different from the ten slope combinations and fertilizer level at age of male maize flowering, and significantly different from the eight slope combinations and other fertilizer levels at age of female maize flowering. Meanwhile, the highest of cob weight was shown by a combination of hilly slopes and fertilizer level of 100 kg/ha which was significantly different from four other treatment combinations only. The highest of grain yiled was shown by the combination of flat slope and fertilizer level of 200 kg/ha, but it was significantly different from only eight other treatment combinations. Whereas the highest of cob weight percentage to grain yiled was shown by the combination of mountainous slopes with a fertilizer level of 100 kga ha^{-1} and significantly different from five other treatment combinations only. The best combination of slope and NPK compound fertilizer on maize yield parameters was flat slope with fertilizer level of 100 kg/ha. This was in line with the report of Ngosong et al., (2019) that N fertilizing between 50 and 100 kg N ha^{-1} was optimal for maize production in Cameroon's volcanic soil.

Table 4-The average of component yield of maize local of Motoro Kiki varietis due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia.

Treatments	Male Flowering Age (DAP)	Female Flowering Age (DAP)	Cob Weight (ton/ha)	Grain Yields (ton/ha)	Percentage of Cob Weight to Grain Yields (%)
Slopes (S):					
S1 (0 – 8%)	44.21 ± 0.84a	47.64 ± 0.70a	1.78 ± 0.27ns	3.06 ± 0.25c	20.43 ± 2.39a
S2 (8 – 15%)	45.53 ± 0.49b	48.92 ± 0.70b	1.51 ± 0.37	2.48 ± 0.37ab	22.49 ± 2.93ab
S3 (15 – 35%)	45.84 ± 0.54b	49.31 ± 0.74b	1.70 ± 0.31	2.56 ± 0.47b	24.27 ± 3.37b
S4 (>35%)	45.53 ± 0.77b	48.82 ± 0.86b	1.55 ± 0.29	2.18 ± 0.33a	25.31 ± 4.14b
NPK Compound (F):					
F0 (0 kg/ha)	45.92 ± 1.17b	49.57 ± 1.24a	1.19 ± 0.24a	2.15 ± 0.46a	20.36 ± 2.20a
F1 (50 kg/ha)	45.01 ± 1.01ab	48.42 ± 0.85b	1.65 ± 0.31b	2.41 ± 0.49a	26.37 ± 3.77b
F2 (100 kg/ha)	44.87 ± 1.14a	48.22 ± 1.15b	1.81 ± 0.26b	2.87 ± 0.50bc	23.03 ± 5.23ab
F3 (150 kg/ha)	45.25 ± 0.57ab	48.59 ± 0.58b	1.74 ± 0.18b	2.49 ± 0.21ab	24.19 ± 1.49ab
F4 (200 kg/ha)	45.34 ± 0.43ab	48.57 ± 0.49b	1.78 ± 0.12b	2.93 ± 0.34c	21.66 ± 1.62a
Combinations (SF):					
S1F0	44.25 ± 1.63bcd	47.75 ± 1.81bcd	1.48 ± 0.42abcde	2.80 ± 0.67abcd	19.71 ± 0.85cde
S1F1	43.50 ± 0.28cd	47.17 ± 0.28cd	2.08 ± 0.21ab	3.23 ± 0.42ab	21.21 ± 3.68abcde
S1F2	43.35 ± 0.12d	46.80 ± 0.05d	1.49 ± 0.68abcde	3.20 ± 0.18ab	16.94 ± 7.83e
S1F3	44.52 ± 1.06bcd	47.86 ± 0.94bcd	1.87 ± 0.32abc	2.78 ± 0.06abcd	23.50 ± 3.25abcde
S1F4	45.42 ± 0.49abcd	48.61 ± 0.54abcd	1.95 ± 0.03abc	3.30 ± 0.11a	20.77 ± 1.29abcde
S2F0	45.98 ± 1.15ab	49.85 ± 1.01ab	0.92 ± 0.13e	2.04 ± 0.42de	18.08 ± 5.14de
S2F1	45.67 ± 0.71ab	48.91 ± 0.68abc	1.35 ± 0.25bcde	2.18 ± 0.67cde	25.93 ± 1.17abcde
S2F2	44.71 ± 0.68abcd	47.90 ± 0.61bcd	1.77 ± 0.05abcd	2.91 ± 0.47abcd	23.06 ± 5.15abcde
S2F3	45.48 ± 0.45abc	48.83 ± 0.33abcd	1.76 ± 0.44abcd	2.48 ± 1.03abcde	23.83 ± 5.83abcde
S2F4	45.80 ± 0.90ab	49.08 ± 0.82abc	1.73 ± 0.47abcd	2.79 ± 0.45abcd	21.58 ± 0.97abcde
S3F0	46.65 ± 0.26a	50.46 ± 0.38a	1.28 ± 0.10cde	1.99 ± 0.24de	23.33 ± 1.86abcde
S3F1	45.30 ± 1.79abcd	48.65 ± 1.72abcd	1.59 ± 0.14abcde	2.19 ± 0.44cde	28.87 ± 3.52abc
S3F2	46.00 ± 0.57ab	49.51 ± 0.73ab	2.13 ± 0.02a	3.22 ± 0.39ab	22.42 ± 2.67abcde
S3F3	45.86 ± 0.94ab	49.23 ± 0.94abc	1.83 ± 0.01abcd	2.30 ± 0.34bcde	26.38 ± 3.49abcd
S3F4	45.38 ± 0.07abcd	48.70 ± 0.00abcd	1.67 ± 0.17abcd	3.09 ± 0.46abc	20.32 ± 0.93bcde
S4F0	46.80 ± 0.42a	50.20 ± 0.33a	1.09 ± 0.38de	1.76 ± 0.46e	20.30 ± 0.78bcde
S4F1	45.55 ± 0.49abc	48.95 ± 0.26abc	1.57 ± 0.27abcde	2.05 ± 0.36de	29.48 ± 0.81ab
S4F2	45.43 ± 0.52abc	48.65 ± 0.45abcd	1.83± 0.09abcd	2.16 ± 0.10cde	29.71 ± 3.46a
S4F3	45.11 ± 0.68abcd	48.41 ± 0.59abcd	1.48 ± 0.12abcde	2.38 ± 0.23abcde	23.08 ± 1.32abcde
S4F4	44.75 ± 1.58abcd	47.90 ± 1.84bcd	1.77 ± 0.07abcd	2.53 ± 0.39abcde	23.96 ± 3.55abcde
CV (%)	1.88	1.77	18.54	18.53	16.34

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

Relative agronomic and economic fertilization effectiveness

The highest of relative agronomic effectiveness (RAE) values, the ratio of economic fertilization effectiveness (EFE) with subsidized fertilizer and non-subsidized was shown by flat slopes (0-8%) which differ significantly by undulating slopes (8-15%) and mountainous slopes (>35%) on RAE, significantly different from all slopes in the EFE subsidized and non-subsidized ratio (Table 5), in other to the distribution was obtained following the RAE pattern S1> S3> S2> S4. Provision of standard or recommended of NPK Fertilizers (300 kg/ha NPK+250 kg/ha Urea) shows a higher RAE value (100) than other fertilizer doses to maize plants (Kasno, 2010; Wijaya et al., 2015; Erselia et al., 2017; Subandi et al., 2017), in sugarcane (Zulkarnain et al., 2017). Furthermore, the highest of the RAE value, EFE subsidized and non-subsidized ratio with NPK compound fertilization was shown by fertilizer level of 200 kg/ha which was not significantly different with fertilizer level of 50 kg/ha and 100 kg/ha at RAE, and has not significantly different only with the level of 100 kg/ha in the EFE subsidized and non-subsidized ratio, so as the distribution was obtained following the pattern F4> F2> F3> F1> F0.

Table 5-Relative agronomic effectiveness (RAE) and economic fertilizer effectiveness (EFE) of maize yields with NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Grain Yields (ton/ha)	RAE (%)	Ratio of EFE (Subsidized Fertilizer)	Ratio of EFE (Non-Subsidized Fertilizer)
Slopes (S):				
S1 (0 – 8%)	3.06 ± 0.25c	131.98 ± 127.63a	4.66 ± 0.38a	1.34 ± 0.11a
S2 (8 – 15%)	2.48 ± 0.37ab	45.77 ± 38.99b	3.77 ± 0.57bc	1.08 ± 0.16bc
S3 (15 – 35%)	2.56 ± 0.47b	56.24 ± 55.19ab	3.89 ± 0.85b	1.12 ± 0.24b
S4 (>35%)	2.18 ± 0.33a	33.55 ± 24.19b	3.31 ± 0.46c	0.95 ± 0.13c
NPK Compound (F):				
F0 (0 kg/ha)	2.15 ± 0.46a	0.00 ± 0.00c	3.26 ± 0.69c	0.94 ± 0.20c
F1 (50 kg/ha)	2.41 ± 0.49a	68.50 ± 98.78abc	3.66 ± 0.84c	1.05 ± 0.24c
F2 (100 kg/ha)	2.87 ± 0.50bc	111.47 ± 70.62ab	4.36 ± 0.75ab	1.26 ± 0.22ab
F3 (150 kg/ha)	2.49 ± 0.21ab	28.69 ± 28.59bc	3.79 ± 0.32bc	1.09 ± 0.09bc
F4 (200 kg/ha)	2.93 ± 0.34c	125.77 ± 87.65a	4.45 ± 0.51a	1.28 ± 0.15a
Combinations (SF):				
S1F0	2.80 ± 0.67abcd	0.00 ± 338.69c	4.26 ± 1.01abcd	1.23 ± 0.29abcd
S1F1	3.23 ± 0.42ab	216.57 ± 215.72ab	4.91 ± 0.65ab	1.41 ± 0.19a
S1F2	3.20 ± 0.18ab	201.63 ± 93.48abc	4.87 ± 0.28ab	1.40 ± 0.08ab
S1F3	2.78 ± 0.06abcd	-12.33 ± 31.98c	4.23 ± 0.10abcd	1.22 ± 0.03abcd
S1F4	3.30 ± 0.11a	254.05 ± 58.19a	5.02 ± 0.17a	1.44 ± 0.05a
S2F0	2.04 ± 0.42de	0.00 ± 44.09c	3.10 ± 0.64de	0.89 ± 0.18de
S2F1	2.18 ± 0.67cde	14.41 ± 69.87bc	3.31 ± 1.02cde	0.95 ± 0.29cde
S2F2	2.91 ± 0.47abcd	90.14 ± 49.05abc	4.42 ± 0.72abcd	1.27 ± 0.21abcd
S2F3	2.48 ± 1.03abcde	46.41 ± 107.49abc	3.78 ± 1.57abcde	1.09 ± 0.45abcde
S2F4	2.79 ± 0.45abcd	77.91 ± 46.97abc	4.24 ± 0.68abcd	1.22 ± 0.20abcd
S3F0	1.99 ± 0.24de	0.00 ± 23.75c	3.03 ± 0.36de	0.87 ± 0.10de
S3F1	2.19 ± 0.44cde	19.93 ± 44.03bc	3.33 ± 0.68cde	0.96 ± 0.19cde
S3F2	3.22 ± 0.39ab	121.84 ± 38.66abc	4.90 ± 0.59ab	1.41 ± 0.17ab
S3F3	2.30 ± 0.34bcde	30.75 ± 33.48bc	3.50 ± 0.51bcde	1.01 ± 0.15bcde
S3F4	3.09 ± 0.46abc	108.67 ± 45.97abc	4.69 ± 0.71abc	1.35 ± 0.20abc
S4F0	1.76 ± 0.46e	0.00 ± 37.02c	2.67 ± 0.70e	0.77 ± 0.20e
S4F1	2.05 ± 0.36de	23.07 ± 29.31bc	3.11 ± 0.55de	0.89 ± 0.16de
S4F2	2.16 ± 0.10cde	32.28 ± 8.21bc	3.28 ± 0.15cde	0.94 ± 0.04cde
S4F3	2.38 ± 0.23abcde	49.93 ± 18.84abc	3.62 ± 0.36abcde	1.04 ± 0.10abcde
S4F4	2.53 ± 0.39abcde	62.46 ± 31.35abc	3.85 ± 0.59abcde	1.11 ± 0.17abcde
CV (%)	18.53	160.21	18.52	18.57

Mean ± standard deviation, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The highest of RAE, the EFE subsidized and non-subsidized ratio in the combination of slope and NPK compound fertilization has shown by the combination of flat slope with fertilizer level 200 kg/ha which was significantly different from the ten other treatment combinations at RAE value and significantly different from eight other treatment combinations at the EFE subsidized and non-subsidized ratio (Table 5). While the lowest RAE value was indicated by the combination of flat slope with fertilizer level of 150 kg/ha which was significantly different from the combination of flat slope and fertilizer level of 50 kg/ha only, the EFE subsidized and non-subsidized ratio was indicated by the combination of mountainous slopes with fertilizer level of 0 kg/ha and significantly different from ten other treatment combinations. Thus, the combination of a flat slope with a fertilizer level of 100 kg/ha is the best combination that can be applied by maize farmers. This was in line with the report of Wijaya et al. (2015) that fertilizing urea at 100 kg/ha, SP-36 at 200 kg/ha and KCl at 100 kg/ha showed the highest EFE ratio in both subsidized and non-subsidized fertilizers. However, if farmers will continue to maize cultivating on sloping land, it was recommended to arrive at hilly slopes (15-35%) with fertilizer levels of 100 kg/ha only.

CONCLUSION

The slope and NPK compound fertilization can increase the maize growths. The best combination in increasing plant height and leaves number was the combination of flat slope and fertilizer level of 100 kg/ha. The slope and NPK compound fertilization can increase the maize yields. The best combination in accelerating the age of male and female maize flowering, increasing the grain yield was the combination of flat slope and fertilizer level of 100 kg/ha. While on cob weight was combination of hilly slope and fertilizer level of 100 kg/ha, whereas on the percentage of cob weight to grain yield was a combination of mountainous slope and fertilizer level of 100 kg/ha. The slope and NPK compound fertilization can increase the RAE percentage, the EFE subsidized and non-subsidized ratio. The best combination of flat slopes and compound NPK fertilization level of 200 kg/ha has significantly increase the percentage of RAE, the EFE subsidized and non-subsidized ratio, but relatively equal to the the level of 100 kg/ha. If farmers will continue to maize cultivating on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg/ha only.

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EFFECT OF SLOPES AND COMPOUND NPK FERTILIZER ON GROWTH AND YIELD OF MAIZE LOCAL VARIETIES, RELATIVE AGRONOMIC AND ECONOMIC FERTILIZER EFFECTIVENESS TO INCEPTISOL BUMELA, INDONESIA

Nurdin*
Doctorate Program of Agriculture Science, Brawijaya University, Veteran street 65145 Malang, Indonesia.

Mochtar Lutfi Rayes, Soemarno, Sudarto
Department of Soil Science, Faculty Agriculture, Brawijaya University, Veteran Street 65145 Malang, Indonesia.

Nikmah Musa, Muhajir Dunggio
Department of Agrotechnology, Faculty of Agriculture, Gorontalo State University, Genderal Sudirman Street 96122 Gorontalo, Indonesia

*Email: nurdin@ung.ac.id

ABSTRACT

Maize cultivation has been carried out on the mountainous slopes with high fertilizer inputs, but maize productivity is still low. This study investigates the effect of slope and NPK compound fertilization as well as the best combination of growth and yield of local maize, relative agronomic effectiveness (RAE) percentage and economic fertilizer effectiveness (EFE) ratio in Inceptisol Bumela Indonesia. Slope variations (0-8, 8-15, 15-35, >35%) are combined with compound NPK fertilizer levels (0, 50, 100, 150, 200 kg ha^{-1}) with split plot design. Growth data was recorded for changes in plant height and leaves number from 7 DAP to 42 DAP, while yield and yield components are recorded at harvest. The results showed that slope and NPK compound fertilization can increase the growth and yield of maize plants. The combination of flat slopes and fertilizer level of 100 kg ha^{-1} was the best combination in increasing plant height and the leaves number, accelerate the age of male and female flowering flowers, cob weight, grain yield and percentage of cob weight to grain yields. This combination was also able to increase the percentage of RAE, the ratio of EFE subsidized and non-subsidized. If farmers will continue to cultivate maize on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg ha^{-1} only.

KEY WORDS: Slope, fertilizer, NPK compound, growth, yield, maize.

Maize is an excellent commodity in Gorontalo province of Indonesia. Gorontalo Province maize production until 2018 has reached 1.7 million tons or increased by 9.3% from the previous year with a productivity of 5.0 t ha^{-1} (BPS, 2019) which places Gorontalo Province as one of the largest maize producers in Indonesia (Yunus et al., 2018). Maize was cultivated from generation to generation by local farmers (Ardiani, 2009; Fadhilah, 2013) using maize local varieties. However, since 2002 through the agropolitan programs with maize commodity (Jocom et al., 2009; Grace, 2010), the use of local varieties has changed to maize hybrid and composite varieties, so as the maize local varieties were rarely planted and threatened with extinction.

One of Gorontalo's local germplasm was the Motoro Kiki variety (Zubachtirodin and Kasim, 2012). Motoro Kiki is a Gorontalo maize local variety (Yasin et al., 2007) that aged 70-80 day after planting (DAP), yield potential was 3 t ha^{-1} of grain yield, resistant to downy mildew and leaf rust, and was well planted in the lowlands to the highlands (IAARD, 2009). Maize local has better growth than hybrid and maize composite, but the yield component shows the opposite patterns (Kaihatu and Pesireron, 2016).

Maize cultivation in Gorontalo Province region was very massive and has carried out on upland with a slope of 0% (flat) to mountainous land (slope >35%) which was vulnerable to land degradation. In fact, soil erosion that occurred from the Agropolitan maize planting area reported by Husain et al., (2004) as many as 1,396 t ha^{-1} $year^{-1}$. If this condition was left, it will threaten the sustainability of maize farming. Upland for maize cultivation in Bumela Village was generally on Inceptisols (Indonesian Soil and Agroclimate Research Center Team, 1995). Inceptisol was a relatively young soil and its development was a level above of the Entisols (Rachim, 2007), including having a cambic horizons with a percentage of Na can be exchanged by 15% or more (Soil Survey Staff, 2014). Inceptisol has the potential to be developed (Nursyamsi et al., 2002; Hermawan et al., 2018) because it covers 70 million hectares in Indonesia (Kasno, 2009; Muyassir et al., 2012; Hermawan et al., 2018). However, these soils generally have low soil fertility and organic matter content (Abdurachman et al., 2008; Arviandi et al., 2015). Meanwhile, the high intensity of tillage for maize cultivation has led to a decrease in soil fertility (Lorenz et al., 2000; Husain et al., 2002; Pomalingo and Husain, 2003), so as the maize productivity is low, although fertilizer application exceeds recommendations.

A literature study on the results of the effect of slope and compound NPK fertilization combined with the specific growth and yield of maize local varieties has not been found. While information on the performance of growth and yield of maize local on various slopes combined with the level of NPK compound fertilization is very important for farmers and policy makers, especially in the Gorontalo Province. In fact, maize farmers continue to cultivate on sloping land of >25% with less fertilizer input or exceed the recommended fertilizer levels, so this research was important to done. This study aims to investigate the growth and yield of maize local variety of Motoro Kiki, the relative agronomic effectiveness (RAE) and economic fertilization effectiveness (EFE) on various slopes and NPK compound fertilization to Inceptisol Bumela, Indonesia.

MATERIAL AND METHODS

Site study area

The study was conducted to four months (December 2019 to March 2020) on the toposequence of farmers maize land in Bumela Village, Bilato District, Gorontalo Regency, Gorontalo Province, Indonesia. Specifically geographical, the experimental field was rectangular located at 0°36'11.98"-0°36'11.46" N and 122°40'01.33"-122°40'02.49" E at an altitude of 314 m above sea level (m asl), and 0°36'08.39"-0°36'08.11" N and 122°40'00.31"-122°40'01.45" E with an altitude of 339 m asl.

Table 1-Some soil physico-chemical properties were selected at a depth of 0-30 cm

No	Soil properties	Value	Criterion*
1.	Textures:		
a.	Sand (%)	62.00	Sandy clay
b.	Silt (%)	21.50	
c.	Clay (%)	16.60	
2.	pH (H2O	5.65	Rather sour
3.	Soil organik carbon (%)	0.67	Very low
4.	Total nitrogen (%)	0.07	Very low
5.	P-Bray 1 available (mg ka^{-1})	4.02	Low
6.	Cations exchangeable:		
a.	K^+	0.29	Low
b.	Na^+	2.16	Low
c.	Ca^{2+}	3.86	Low
d.	Mg^+	0.38	Low
7.	Cation exchange capacity (cmol kg^{-1})	8.94	Low
8.	Base saturation (%)	79.88	High
9.	Na saturation (%)	24.27	High

**Eviyati and Soleman (2009).*

This soil is very dark gray brownish (10YR 3/2), granular of soil structure and sandy clay of texture, cation exchange capacity of 8.94 cmol kg^{-1} and base saturation 79.88%, Na saturation of 24.17% (Table 1). Annual average rainfall of 1,245.90 mm with annual average temperature of 28.02ºC (BWS Sulawesi II, 2019) and potential evapotranspiration of 152.95 mm, so the soil moisture regime was Ustic (106 dry days without humid days) and the soil temperature regime was Isohyperthermic. Based on the morphology, soil physicochemical properties and other properties, the soil in the experimental field was classified as Oxic Humustepts (Soil Survey Staff, 2014).

Research material

The compound fertilizer used was NPK Phonska fertilizer with nutrient content (%) of 15-15-15 and Gorontalo maize local was used Motoro Kiki variety. The land was used upland owned by maize farmers with Inceptisol (Oxic Humustepts) soil type. This upland was used starting from flat (0-8%), undulating (8-15%), hilly (15-35%) and mountainous land (> 35%) on one toposequency.

Field experimentals

The field experimental were designed following a split plot design. Four slope treatments were slope of 0-8% (S1), 8-15% (S2), 15-35% (S3) and slope >35% (S4) as the main plots. While the five NPK compound fertilizer treatments, namely 0 kg ha^{-1} (F0), 50 kg ha^{-1} (F1), 100 kg ha^{-1} (F2), 150 kg ha^{-1} (F3), and the level of 200 kg ha^{-1} (F4) as subplots. Each treatment was repeated three replication, so as 60 treatment plot combinations were obtained. The treatment plot was made 2 x 2 m by smoothing the soil evenly with hoe and shovel. The distance between plots was made 1 m to facilitate accessibility to and from the treatment plot.

Maize was planted with a distance of 20 x 40 cm in the planting hole of 2 maize seeds (December 26, 2019), so as to get 50 plant populations per plot. At the maize age of 7 day after planting (DAP), weed cleansing and thinning into 1 plant per holes. The first fertilization was done (1/2 level of fertilization per treatment) and plant embellishment was followed. Weed cleansing and embellishment was done when growing weeds manually with a hoe. At the maize age of 30 DAP, the second fertilization (the remaining 1/2 level of fertilization per treatment) was continued with plant embellishment. Maintenance continues until the harvest stage. Maize harvesting was done when the physical condition of the maize was dry and yellows (26 March 2020) or ± 90 DAP.

Observation of maize growth variables, including plant height (cm) and leaves number was carried out from plants aged 7 DAP to male flowers (± 42 DAP) on ten selected plants per plot. While the maize yield variables, including age of male and female flowering (DAP) were observed when maize flowers first appeared, the cob weight (t ha^{-1}) was weighed after the maize seeds were separated from the cob, the grain yield (t ha^{-1}) was weighed after the maize seeds were dried under 5 days sun exposure (± 15% moisture content) and the percentage of cob weight to grain yields (%).

Data analysis

NPK compound fertilizer applied, either singly or in combination was tested by relative agronomic effectiveness or RAE (Mackay et al., 1984; Chien, 1996) with the following equation:

$$RAE = \frac{Yt - Yo}{Ys - Yo} x\,100$$

Where: Yt = maize yield on the tested fertilizer (t ha^{-1}), Ys = maize yield standard (t ha^{-1}), and Yo = maize yield on the control treatment (t ha^{-1}). The greater the percentage of RAE, the better the effectiveness of fertilizer relative to agronomic traits. Meanwhile, to find out the fertilizer used has a good economic value, an economic fertilizer effectiveness (EFE) was carried out with the following equation:

$$Ratio\ EFE = \frac{P\ x\ Q}{C}$$

Where: P = price of maize per kg (IDR Kg^{-1}), Q = total yield (kg ha^{-1}), and C = price of fertilizer (IDR Ha^{-1}). If the EFE ratio was >1, the fertilizer tested has good economic value (Saeri and Suwono, 2012; Wijaya et al., 2015).

The price of maize per kg in the study area was IDR 3,500. While the price of Phonska compound NPK fertilizer consists of two, namely NPK Phonska was subsidized by the government at a price of IDR 2,300 and non-subsidized at a price of IDR 8,000. The two forms of NPK fertilizer were used as a comparison material as well as consideration in making the best agronomic and economical NPK compound fertilizer selection decisions. All data obtained were analyzed with ANOVA of split plot design divided into patterns 4^5. If there was a treatment that has a significant effect, then it was continued with the Duncan Multiple Range Test (DMRT) at the test level P >0.05 with the tools of the Statistical Analysis System (SAS) program.

RESULT AND DISCUSSION

Effect of slope and NPK compound fertilizer on maize growth

Slopes and NPK compound fertilization showed has significant effect on the plant height at the age of 14, 21, 28, 35, and 42 DAP, except at the age of 7 DAP in all treatments and at the age of 14 DAP in the treatment of compound NPK fertilizer that has not significantly affected (Table 2).

Table 2-The average of plant height of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Plant Heigh (cm)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	16.37 ± 0.40ns	33.28 ± 1.89ab	79.70 ± 4.31c	95.92 ± 6.48b	137.33 ± 4.49c	180.87 ± 10.48b
S2 (8 – 15%)	16.06 ± 0.38	34.97 ± 1.87b	69.99 ± 4.32b	83.90 ± 8.08a	120.67 ± 11.47ab	160.46 ± 13.22a
S3 (15 – 35%)	16.13 ± 0.40	32.36 ± 0.87a	63.41 ± 2.89a	89.26 ± 3.13a	113.94 ± 3.97a	159.33 ± 8.48a
S4 (>35%)	16.05 ± 0.62	33.02 ± 1.23ab	68.77 ± 2.93b	99.01 ± 5.19b	127.07 ± 7.89b	160.52 ± 9.95a
NPK Compound (F):						
F0 (0 kg ha^{-1})	16.45 ± 0.48ns	34.00 ± 0.65ns	69.80 ± 4.68ab	88.57 ± 11.43a	117.13 ± 12.57a	150.65 ± 10.18a
F1 (50 kg ha^{-1})	15.97 ± 0.17	33.31 ± 2.09	70.32 ± 8.59ab	92.70 ± 6.39ab	124.86 ± 10.99abc	164.78 ± 15.32b
F2 (100 kg ha^{-1})	16.33 ± 0.39	34.33 ± 2.88	72.38 ± 9.92b	96.53 ± 5.90b	131.45 ± 12.71c	173.05 ± 14.53b
F3 (150 kg ha^{-1})	15.97 ± 0.66	32.22 ± 0.71	66.72 ± 5.81a	88.65 ± 7.05a	121.95 ± 8.25ab	168.51 ± 7.38b
F4 (200 kg ha^{-1})	16.02 ± 0.36	33.16 ± 1.20	73.10 ± 6.42b	93.65 ± 10.16ab	128.36 ± 11.33bc	169.47 ± 11.83b
Combinations (SF):						
S1F0	16.35 ± 0.49ns	33.55 ± 3.18abcd	76.55 ± 8.70abc	100.00 ± 17.11abc	134.50 ± 12.45abcd	163.95 ± 12.52cdef
S1F1	15.85 ± 0.92	32.75 ± 0.35abcd	81.75 ± 1.48ab	98.90 ± 1.84abcd	139.80 ± 5.66ab	187.65 ± 9.69ab
S1F2	16.50 ± 0.42	36.40 ± 4.81ab	84.45 ± 6.29a	102.70 ± 3.39ab	143.50 ± 7.07a	190.60 ± 6.93a
S1F3	16.95 ± 3.89	31.65 ± 5.30bcd	73.95 ± 13.79abcd	89.55 ± 18.60bcde	132.00 ± 4.38abcde	178.75 ± 13.22abcd
S1F4	16.20 ± 1.13	32.05 ± 2.90bcd	81.80 ± 4.53ab	88.45 ± 1.63bcde	136.85 ± 4.31abc	183.40 ± 3.54abc
S2F0	16.20 ± 0.00	34.40 ± 5.37abcd	67.45 ± 8.56cdef	73.30 ± 10.89f	107.30 ± 13.01h	139.20 ± 13.15g
S2F1	16.20 ± 1.13	36.35 ± 2.90abc	71.50 ± 3.54bcdef	85.10 ± 3.54cdef	118.10 ± 2.97defgh	158.15 ± 2.76efg
S2F2	16.55 ± 0.21	37.20 ± 3.68a	76.15 ± 1.63abc	95.70 ± 1.27abcde	138.95 ± 16.33ab	174.45 ± 16.19abcde
S2F3	15.60 ± 1.56	32.40 ± 0.42abcd	64.70 ± 1.98cdef	81.10 ± 1.41ef	120.90 ± 7.64cdefgh	165.55 ± 2.05cdef
S2F4	15.75 ± 0.21	34.50 ± 1.13abcd	70.15 ± 6.01bcdef	84.30 ± 3.82def	118.10 ± 10.89defgh	164.95 ± 2.90cdef
S3F0	16.10 ± 0.42	33.35 ± 2.76abcd	66.05 ± 1.48cdef	87.30 ± 0.99cdef	108.50 ± 1.27gh	148.95 ± 4.60fg
S3F1	16.00 ± 0.00	31.55 ± 2.05cd	61.80 ± 10.18ef	89.85 ± 3.89bcde	115.30 ± 3.68efgh	158.40 ± 10.75efg
S3F2	16.55 ± 0.78	31.50 ± 0.99d	62.20 ± 3.54def	88.80 ± 2.97bcde	114.90 ± 2.69efgh	172.05 ± 8.70abcde
S3F3	15.55 ± 1.06	33.15 ± 1.06abcd	60.15 ± 3.32f	86.10 ± 0.28cdef	111.90 ± 0.57fgh	161.45 ± 4.88def
S3F4	16.45 ± 1.06	32.25 ± 2.90bcd	66.85 ± 1.63cdef	94.25 ± 2.76abcde	119.10 ± 0.99defgh	155.80 ± 0.85efg
S4F0	17.15 ± 0.78	34.70 ± 0.57abcd	69.15 ± 3.04cdef	93.70 ± 5.66abcde	118.25 ± 14.07defgh	150.50 ± 7.50fg
S4F1	15.85 ± 0.35	32.60 ± 1.13abcd	66.25 ± 2.62cdef	96.95 ± 5.87abcd	126.25 ± 12.52abcdefg	154.95 ± 1.77efg
S4F2	15.75 ± 0.35	32.25 ± 2.33bcd	66.75 ± 4.17cdef	98.95 ± 5.16abcd	128.45 ± 13.65abcdef	155.10 ± 11.60efg
S4F3	15.80 ± 0.28	31.70 ± 0.42bcd	68.10 ± 5.94cdef	97.85 ± 7.57abcd	123.00 ± 8.91bcdefgh	168.30 ± 7.21bcdef
S4F4	15.70 ± 0.57	33.85 ± 1.48abcd	73.60 ± 3.54abcde	107.60 ± 14.42a	139.40 ± 28.43ab	173.75 ± 27.08abcde
CV (%)	7.18	5.88	6.93	6.75	5.84	5.05

Mean ± standard deviation, DAP: day after planting, ns: not significant, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

This was be fathomed because it was not directly related to the plant physiological aspects, but directly related to soil characteristics. Slopes were closely related to the quantity of soil organic carbon, total N, and enzyme activity by changing the rate of litter

decomposition and soil microbial activity (Nahidan et al., 2015). The highest rate of plant height increase at the age of 28 DAP with an average percentage of plant height increase of 111.05% in all treatments and decreased until the age of 42 DAP. While, the highest rate of plant height increase with an average percentage of plant height increase of 70.56% was indicated by the slope 0% (flat) and NPK compound fertilizer as much as 50 kg ha^{-1}, while the rate of plant height increase was lowest with an average percentage of plant height increase of 58.12% only was shown by the slopes >35% (mountainous) and NPK compound fertilizer as much as 0 kg ha^{-1}.

Apparently, the effect of slopes began to be seen clearly in plant height from the age of 14 DAP to 42 DAP, where the flat slope had a significant effect on plant height and the peak effect of the slope was more pronounced at plant height aged of 35 and 42 DAP, followed by a undulating slope. The position of the slope has a significant effect on the maize growth (Changere and Lal, 1997). Hilly and mountainous slopes will receive more sunlight than undulating and flat slopes, so that decomposition of organic matter and nutrient cycling was better. Humidity is a basic environmental factor in a relatively dry area, so higher humidity at the shady slopes location can lead to better nutrition cycles and higher microbial community activity (Xue et al., 2018). The levels of C-organic, total N, P are available and K can be exchanged at the study site is relatively low (Table 1), so fertilizing action was needed. While the effect of NPK compound fertilizer began to be seen clearly in plant height later on from the age of 21 DAP to 42 DAP, where the fertilizing level of 100 kg ha^{-1} showed the highest plant height from the age of 28 DAP, 35 and 42 DAP, but it was not significantly different from the fertilizer level of 50 kg ha^{-1} and 200 kg ha^{-1} at the age of 21 DAP, 28, 35 and 42 DAP, except with fertilizer levels 0 kg ha^{-1} and 150 kg ha^{-1} were significantly different at the age of 28 DAP and 35 DAP. The NPK fertilization has a significant effect on the agronomic parameters of maize (Achiri et al., 2017). Nitrogen is another important soil nutrient that affects plant growth and water use efficiency (Sardans et al., 2008). The application of Phosphor fertilizer increases the efficient utilization of N fertilizer on the production of maize biomass (Mensah and Mensah, 2016). Potassium is needed for maize growth (Solihin et al., 2019).

The combination of slopes and NPK compound fertilizers began to showing a significant effect on plant height aged of 14 DAP to 42 DAP, while at age of 7 DAP had no significant effect (Table 2). The combination of flat slope (0-8%) to undulating slope (8-15%) with NPK fertilizer compound level of 100 kg ha^{-1} shows the highest plant height at the age of 21 DAP to 42 DAP. While on a combination of hilly slopes (15-35%) and mountainous slopes (>35%) with all levels of fertilization was relatively varied. However, if the lands with these slopes will still be used for maize cultivation, then it will be sought only to land with hilly slopes (15-35%) combined with NPK compound fertilizer levels of 100 kg ha^{-1} because plant height reaches of 174.45 cm at age of 42 DAP. At low fertilization rates, the amount of N and K absorbed by plants increases with the amount of fertilizer applied (Niu et al., 2013). Maize plants absorb large amounts of N from the soil at V6 and maximum absorption occurs before silking (Ma' et al., 2003).

The effect of the slope on the leaves number shows the significant effect from the age of 7 DAP to 42 DAP, while the effect of compound NPK fertilization shows the significant effect later starting at age of 21 DAP to 42 DAP (Table 3). The highest rate of leaves number increasing occurred at the age of 14 DAP with an average percentage of leaves number increase of 79.70% in all treatments and decreased until the age of 42 DAP. The rate of increasing the leaves number with an average percentage leaves number increase by 38.16% was indicated by the slopes >35% (mountainous) and NPK compound fertilizer as much as 150 kg ha^{-1}, while the rate of increasing the leaves number with an average the percentage of leaves number increase was 29.94% only, as indicated by the slopes 15-35% (hilly) and NPK compound fertilizer as much as 200 kg ha^{-1}. Leaves number of maize increased significantly as the plants aged with NPK

fertilizing (Titah et al., 2016). Effect of slope on the leaves number at age of 7 DAP shows the highest leaves number on hilly slopes (15-35%) and not significantly different from flat slopes (0-8%) and undulating slopes (8-15%), but significantly different from slopes mountainous (>35%). At the age of 14 DAP, the effect of hilly slopes still shows the highest leaves number and was significantly different from flat slopes and undulating slopes, while those with mountainous slopes are not significantly different. At the age of 21 DAP and 28 DAP, the effect of flat slope has shown the highest leaves number and was significantly different from all slope classes, except at the age of 28 DAP which was only significantly different from hilly slopes. While at the age of 35 DAP and 42 DAP, the effect of mountainous slopes shows the highest leaves number and was not significantly different from flat slopes.

Table 3-The average of number leaves of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Leaves Number (strands)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	3.26 ± 0.12b	5.33 ± 0.09a	8.32 ± 0.38a	9.68 ± 0.52b	10.99 ± 0.23c	12.24 ± 0.38bc
S2 (8 – 15%)	3.22 ± 0.08b	5.78 ± 0.20b	8.00 ± 0.15b	9.40 ± 0.38b	10.49 ± 0.48b	11.70 ± 0.46a
S3 (15 – 35%)	3.34 ± 0.15b	6.02 ± 0.22c	7.91 ± 0.18b	9.07 ± 0.29a	10.22 ± 0.28a	12.02 ± 0.40b
S4 (>35%)	2.99 ± 0.11a	5.83 ± 0.06bc	7.90 ± 0.29b	9.50 ± 0.34b	11.01 ± 0.33c	12.51 ± 0.53c
NPK Compound (F):						
F0 (0 kg ha^{-1})	3.22 ± 0.06ns	5.70 ± 0.32ns	7.73 ± 0.21a	8.88 ± 0.25a	10.22 ± 0.41a	11.43 ± 0.25a
F1 (50 kg ha^{-1})	3.15 ± 0.15	5.87 ± 0.31	8.18 ± 0.55b	9.48 ± 0.54b	10.55 ± 0.54b	12.21 ± 0.51b
F2 (100 kg ha^{-1})	3.23 ± 0.23	5.70 ± 0.20	8.07 ± 0.22b	9.63 ± 0.43b	10.93 ± 0.27c	12.38 ± 0.19b
F3 (150 kg ha^{-1})	3.13 ± 0.21	5.65 ± 0.29	8.06 ± 0.02b	9.51 ± 0.23b	10.87 ± 0.48c	12.33 ± 0.24b
F4 (200 kg ha^{-1})	3.26 ± 0.22	5.77 ± 0.44	8.10 ± 0.15b	9.53 ± 0.28b	10.80 ± 0.42bc	12.21 ± 0.66b
Combinations (SF):						
S1F0	3.30 ± 0.00abc	5.25 ± 0.07e	8.00 ± 0.28cde	9.10 ± 0.42cdef	10.60 ± 0.42abc	11.65 ± 0.64cde
S1F1	3.20 ± 0.14abc	5.45 ± 0.21cde	8.95 ± 0.49a	10.25 ± 1.06a	11.15 ± 0.49ab	12.65 ± 0.49ab
S1F2	3.45 ± 0.21ab	5.40 ± 0.14cde	8.40 ± 0.28b	10.20 ± 0.14ab	11.15 ± 0.64ab	12.40 ± 0.57abc
S1F3	3.20 ± 0.42abc	5.25 ± 0.21e	8.10 ± 0.42cde	9.50 ± 0.28abcde	11.00 ± 0.14ab	12.40 ± 0.57abc
S1F4	3.15 ± 0.21abc	5.30± 0.28de	8.15 ± 0.35bcd	9.35 ± 0.64cdef	11.05 ± 0.49ab	12.10 ± 0.28bcd
S2F0	3.20 ± 0.28abc	5.70 ± 0.14bcde	7.80 ± 0.00efg	8.75 ± 0.21ef	9.95 ± 0.07e	11.15 ± 0.07e
S2F1	3.30 ± 0.14abc	6.10 ± 0.42ab	8.15 ± 0.21bcd	9.45 ± 0.07bcde	10.05 ± 0.07de	11.50 ± 0.14de
S2F2	3.15 ± 0.07abc	5.85 ± 0.21abcd	7.90 ± 0.00def	9.70 ± 0.85abcd	11.05 ± 0.78ab	12.25 ± 1.06bcd
S2F3	3.15 ± 0.21abc	5.65 ± 0.07bcde	8.05 ± 0.07cde	9.50 ± 0.28abcde	10.85 ± 0.07abc	12.10 ± 0.14bcd
S2F4	3.30 ± 0.14abc	5.60 ± 0.14bcde	8.10 ± 0.00cde	9.60 ± 0.57abcd	10.55 ± 0.21bcd	11.50 ± 0.42de
S3F0	3.25 ± 0.49abc	5.95 ± 0.49abc	7.60 ± 0.14g	8.60 ± 0.14f	9.80 ± 0.28e	11.30 ± 0.28e
S3F1	3.15 ± 0.07abc	6.10 ± 0.28ab	8.00 ± 0.28cde	9.00 ± 0.00def	10.15 ± 0.07de	12.20 ± 0.14bcd
S3F2	3.40 ± 0.14ab	5.75 ± 0.35bcde	8.00 ± 0.14cde	9.20 ± 0.00cdef	10.55 ± 0.07bcd	12.25 ± 0.35bcd
S3F3	3.35 ± 0.07abc	5.95 ± 0.21abc	8.05 ± 0.07cde	9.25 ± 0.07cdef	10.25 ± 0.07de	12.20 ± 0.14bcd
S3F4	3.55 ± 0.07a	6.35 ± 0.07a	7.90 ± 0.14def	9.30 ± 0.00cdef	10.35 ± 0.21cde	12.15 ± 0.07bcd
S4F0	3.15 ± 0.07abc	5.90 ± 0.14abc	7.55 ± 0.07g	9.10 ± 0.00cdef	10.55 ± 0.21bcd	11.65 ± 0.49cde
S4F1	2.95 ± 0.07bc	5.85 ± 0.21abcd	7.65 ± 0.07fg	9.25 ± 0.07cdef	10.85 ± 0.07abc	12.50 ± 0.28ab
S4F2	2.95 ± 0.07bc	5.80 ± 0.28abcde	8.00 ± 0.14cde	9.45 ± 0.07bcde	11.00 ± 0.14ab	12.65 ± 0.07ab
S4F3	2.85 ± 0.07c	5.75 ± 0.07bcde	8.05 ± 0.21cde	9.80 ± 0.14abcd	11.40 ± 0.14a	12.65 ± 0.64ab
S4F4	3.05 ± 0.21abc	5.85 ± 0.07abcd	8.25 ± 0.07bc	9.90 ± 0.14abc	11.25 ± 0.21a	13.10 ± 0.28a
CV (%)	6.39	4.01	1.54	3.48	2.32	2.71

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The effect of NPK compound fertilizer on the leaves number at the age of 7 DAP shows the highest leaves number at the fertilizer level of 200 kg ha^{-1}, while at the age of 14 DAP the highest leaves number at the fertilizer level of 50 kg ha^{-1}, although at the two ages it was not significantly different from all fertilization levels. At the age of 21 DAP, NPK compound fertilization shown has significant effect with the highest leaves number at the fertilizer level of 50 kg ha^{-1} and significantly different from the fertilizer level of 0 kg ha^{-1} only. While at the age of 28 DAP to 42 DAP, the effect of compound NPK fertilizer on the most leaves number was indicated by the fertilizer level of 100 kg ha^{-1} and significantly different from the fertilizer level of 0 kg ha^{-1} only, except at age of 35 DAP apart from being significantly different from the level 0 kg ha^{-1} also with a fertilizer level of 50 kg ha^{-1}. The combination of slope and compound NPK fertilizer shows a significant effect on the leaves number starting at age of 7 DAP to 42 DAP (Table 3). The combination of hilly slopes with NPK compound fertilizer of 200 kg ha^{-1} level shows the highest leaves number at the age of 7 DAP to 14 DAP and was significantly different with the combination of mountainous slopes with fertilizer levels of 50, 100 and 150 kg ha^{-1} at age of 7 DAP only, as well as a combination of flat slope and fertilizer level of 0 kg ha^{-1} to 200 kg ha^{-1}, a combination of undulating slopes with fertilizer levels of 0 kg ha^{-1}, 150 and 200 kg ha^{-1}, a combination of hilly and mountainous slopes with levels 100 kg ha^{-1}. While at the age of 21 DAP, the highest leaves number was indicated by a combination of flat slope and 50 kg ha^{-1} fertilizer level that was significantly different from all treatment combinations. The same pattern was also shown by the highest leaves number at the age of 28 DAP on a combination of flat slope and 50 kg ha^{-1} fertilizer level, but significantly different from the twelve other treatment combinations. At the age of 35 DAP, the effect of mountainous slopes with fertilizer level of 150 kga ha^{-1} combination showed the highest leaves number and was significantly different from nine other treatment combinations, whereas at age of 42 DAP the highest leaves number was indicated by a combination of mountainous slopes with a fertilizer level of 200 kg ha^{-1} and significantly different from thirteen other treatment combinations.

Effect of slopes and NPK compound fertilizer on maize yields

The effects of slopes and compound NKP fertilizers show a significant effect on all yield components (Table 4). On the flat slope (0-8%), the male flowers (42.21 DAP) and the female maize flowers (47.64 DAP) were the most significantly different from the other slopes, while on the hilly slopes (15-35%) the male flowers were the longest (45.84 DAP) and female flowers (49.31 DAP). The highest of cob weight and grain yields on the flat slope (0-8%) that it was significantly different from other slopes, except that the cob weight was not significantly different from other slopes. The highest of cob weight percentage ton grain yield was shown by mountainous slopes (>35%) and has not significantly different from flat slopes. The slope position also has a significant effect on maize yield (Changere and Lal, 1997), as the slope and organic fertilizer have a significant and very significant effect on potato yield (Wati et al., 2014). The 10-22% lower content of organic matter, nitrogen, and phosphorus on the lower middle slope is associated with a decrease in maize yield of 27% compared to the position of the upper middle slope (Wezel et al., 2002).

The effect of NPK compound fertilizer on the age of male and female maize flowers was the fastest out (44.87 DAP and 48.22 DAP respectively) and the highest cob weight was shown by the fertilizer level of 100 kg ha^{-1} which was significantly different with the level of fertilizer 0 kg ha^{-1} only. While the highest of grain yields hass shown by the fertilizer level of 200 kg ha^{-1} but not significantly different from the fertilizer level of 100 kg ha^{-1}, whereas the highest of cob weight percentage to grain yield was indicated by the level of 50 kg ha^{-1} and significantly different with the level of 0 kg ha^{-1} and 200 kg ha^{-1} only. The NPK fertilization has a significant effect on maize yield parameters (Achiri et al., 2017). Flowering time can often be accelerated 3-10 days by application of NPK fertilizer (Gumeleng, 2003). Female maize flowering were most quickly obtained at the fertilizer level of 250 kg ha^{-1} N, 100 kg ha^{-1} P and 75 kg ha^{-1} K whereas the latest were obtained at 0 kg ha^{-1} level (Nurdin et al., 2009). Phosphor is able to increase the photosynthesis process which will further influence the increase in dry weight of plants (Minardi, 2002).

The combination of slope and NPK compound fertilizer shows a significant effect on all yield components (Table 4). The combination of flat slope with NPK compound fertilizer level of 100 kg ha^{-1} shows the age of male and female maize flowering fastest and has significantly different from the ten slope combinations and fertilizer level at age of male maize flowering, and significantly different from the eight slope combinations and other fertilizer levels at age of female maize flowering. Meanwhile, the highest of cob weight was shown by a combination of hilly slopes and fertilizer level of 100 kg ha^{-1} which was significantly different from four other treatment combinations only. The highest of grain yiled was shown by the combination of flat slope and fertilizer level of 200 kg ha^{-1}, but it was significantly different from only eight other treatment combinations. Whereas the highest of cob weight percentage to grain yiled was shown by the combination of mountainous slopes with a fertilizer level of 100 kga ha^{-1} and significantly different from five other treatment combinations only. The best combination of slope and NPK compound fertilizer on maize yield parameters was flat slope with fertilizer level of 100 kg ha^{-1}. This was in line with the report of Ngosong et al., (2019) that N fertilizing between 50 and 100 kg N ha^{-1} was optimal for maize production in Cameroon's volcanic soil.

Table 4-The average of component yield of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia.

Treatments	Male Flowering Age (DAP)	Female Flowering Age (DAP)	Cob Weight (t ha^{-1})	Grain Yields (t ha^{-1})	Percentage of Cob Weight to Grain Yields (%)
Slopes (S):					
S1 (0 – 8%)	44.21 ± 0.84a	47.64 ± 0.70a	1.78 ± 0.27ns	3.06 ± 0.25c	20.43 ± 2.39a
S2 (8 – 15%)	45.53 ± 0.49b	48.92 ± 0.70b	1.51 ± 0.37	2.48 ± 0.37ab	22.49 ± 2.93ab
S3 (15 – 35%)	45.84 ± 0.54b	49.31 ± 0.74b	1.70 ± 0.31	2.56 ± 0.47b	24.27 ± 3.37b
S4 (>35%)	45.53 ± 0.77b	48.82 ± 0.86b	1.55 ± 0.29	2.18 ± 0.33a	25.31 ± 4.14b
NPK Compound (F):					
F0 (0 kg ha^{-1})	45.92 ± 1.17b	49.57 ± 1.24a	1.19 ± 0.24a	2.15 ± 0.46a	20.36 ± 2.20a
F1 (50 kg ha^{-1})	45.01 ± 1.01ab	48.42 ± 0.85b	1.65 ± 0.31b	2.41 ± 0.49a	26.37 ± 3.77b
F2 (100 kg ha^{-1})	44.87 ± 1.14a	48.22 ± 1.15b	1.81 ± 0.26b	2.87 ± 0.50bc	23.03 ± 5.23ab
F3 (150 kg ha^{-1})	45.25 ± 0.57ab	48.59 ± 0.58b	1.74 ± 0.18b	2.49 ± 0.21ab	24.19 ± 1.49ab
F4 (200 kg ha^{-1})	45.34 ± 0.43ab	48.57 ± 0.49b	1.78 ± 0.12b	2.93 ± 0.34c	21.66 ± 1.62a
Combinations (SF):					
S1F0	44.25 ± 1.63bcd	47.75 ± 1.81bcd	1.48 ± 0.42abcde	2.80 ± 0.67abcd	19.71 ± 0.85cde
S1F1	43.50 ± 0.28cd	47.17 ± 0.28cd	2.08 ± 0.21ab	3.23 ± 0.42ab	21.21 ± 3.68abcde
S1F2	43.35 ± 0.12d	46.80 ± 0.05d	1.49 ± 0.68abcde	3.20 ± 0.18ab	16.94 ± 7.83e
S1F3	44.52 ± 1.06bcd	47.86 ± 0.94bcd	1.87 ± 0.32abc	2.78 ± 0.06abcd	23.50 ± 3.25abcde
S1F4	45.42 ± 0.49abcd	48.61 ± 0.54abcd	1.95 ± 0.03abc	3.30 ± 0.11a	20.77 ± 1.29abcde
S2F0	45.98 ± 1.15ab	49.85 ± 1.01ab	0.92 ± 0.13e	2.04 ± 0.42de	18.08 ± 5.14de
S2F1	45.67 ± 0.71ab	48.91 ± 0.68abc	1.35 ± 0.25bcde	2.18 ± 0.67cde	25.93 ± 1.17abcde
S2F2	44.71 ± 0.68abcd	47.90 ± 0.61bcd	1.77 ± 0.05abcd	2.91 ± 0.47abcd	23.06 ± 5.15abcde
S2F3	45.48 ± 0.45abc	48.83 ± 0.33abcd	1.76 ± 0.44abcd	2.48 ± 1.03abcde	23.83 ± 5.83abcde
S2F4	45.80 ± 0.90ab	49.08 ± 0.82abc	1.73 ± 0.47abcd	2.79 ± 0.45abcd	21.58 ± 0.97abcde
S3F0	46.65 ± 0.26a	50.46 ± 0.38a	1.28 ± 0.10cde	1.99 ± 0.24de	23.33 ± 1.86abcde
S3F1	45.30 ± 1.79abcd	48.65 ± 1.72abcd	1.59 ± 0.14abcde	2.19 ± 0.44cde	28.87 ± 3.52abc
S3F2	46.00 ± 0.57ab	49.51 ± 0.73ab	2.13 ± 0.02a	3.22 ± 0.39ab	22.42 ± 2.67abcde
S3F3	45.86 ± 0.94ab	49.23 ± 0.94abc	1.83 ± 0.01abcd	2.30 ± 0.34bcde	26.38 ± 3.49abcd
S3F4	45.38 ± 0.07abcd	48.70 ± 0.00abcd	1.67 ± 0.17abcd	3.09 ± 0.46abc	20.32 ± 0.93bcde
S4F0	46.80 ± 0.42a	50.20 ± 0.33a	1.09 ± 0.38de	1.76 ± 0.46e	20.30 ± 0.78bcde
S4F1	45.55 ± 0.49abc	48.95 ± 0.26abc	1.57 ± 0.27abcde	2.05 ± 0.36de	29.48 ± 0.81ab
S4F2	45.43 ± 0.52abc	48.65 ± 0.45abcd	1.83± 0.09abcd	2.16 ± 0.10cde	29.71 ± 3.46a
S4F3	45.11 ± 0.68abcd	48.41 ± 0.59abcd	1.48 ± 0.12abcde	2.38 ± 0.23abcde	23.08 ± 1.32abcde
S4F4	44.75 ± 1.58abcd	47.90 ± 1.84bcd	1.77 ± 0.07abcd	2.53 ± 0.39abcde	23.96 ± 3.55abcde
CV (%)	1.88	1.77	18.54	18.53	16.34

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

Relative agronomic and economic fertilization effectiveness

The highest of relative agronomic effectiveness (RAE) values, the ratio of economic fertilization effectiveness (EFE) with subsidized fertilizer and non-subsidized was shown by flat slopes (0-8%) which differ significantly by undulating slopes (8-15%) and mountainous slopes (>35%) on RAE, significantly different from all slopes in the EFE subsidized and non-subsidized ratio (Table 5), in other to the distribution was obtained following the RAE pattern S1> S3> S2> S4. Provision of standard or recommended of NPK Fertilizers (300 kg ha^{-1} NPK+250 kg ha^{-1} Urea) shows a higher RAE value (100) than other fertilizer doses to maize plants (Kasno, 2010; Wijaya et al., 2015; Erselia et al., 2017; Subandi et al., 2017), in sugarcane (Zulkarnain et al., 2017). Furthermore, the highest of the RAE value, EFE subsidized and non-subsidized ratio with NPK compound fertilization was shown by fertilizer level of 200 kg ha^{-1} which was not significantly different with fertilizer level of 50 kg ha^{-1} and 100 kg ha^{-1} at RAE, and has not significantly different only with the level of 100 kg ha^{-1} in the EFE subsidized and non-subsidized ratio, so as the distribution was obtained following the pattern F4> F2> F3> F1> F0.

Table 5-Relative agronomic effectiveness (RAE) and economic fertilizer effectiveness (EFE) of maize yields with NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Grain Yields (t ha^{-1})	RAE (%)	Ratio of EFE (Subsidized Fertilizer)	Ratio of EFE (Non-Subsidized Fertilizer)
Slopes (S):				
S1 (0 – 8%)	3.06 ± 0.25c	131.98 ± 127.63a	4.66 ± 0.38a	1.34 ± 0.11a
S2 (8 – 15%)	2.48 ± 0.37ab	45.77 ± 38.99b	3.77 ± 0.57bc	1.08 ± 0.16bc
S3 (15 – 35%)	2.56 ± 0.47b	56.24 ± 55.19ab	3.89 ± 0.85b	1.12 ± 0.24b
S4 (>35%)	2.18 ± 0.33a	33.55 ± 24.19b	3.31 ± 0.46c	0.95 ± 0.13c
NPK Compound (F):				
F0 (0 kg ha^{-1})	2.15 ± 0.46a	0.00 ± 0.00c	3.26 ± 0.69c	0.94 ± 0.20c
F1 (50 kg ha^{-1})	2.41 ± 0.49a	68.50 ± 98.78abc	3.66 ± 0.84c	1.05 ± 0.24c
F2 (100 kg ha^{-1})	2.87 ± 0.50bc	111.47 ± 70.62ab	4.36 ± 0.75ab	1.26 ± 0.22ab
F3 (150 kg ha^{-1})	2.49 ± 0.21ab	28.69 ± 28.59bc	3.79 ± 0.32bc	1.09 ± 0.09bc
F4 (200 kg ha^{-1})	2.93 ± 0.34c	125.77 ± 87.65a	4.45 ± 0.51a	1.28 ± 0.15a
Combinations (SF):				
S1F0	2.80 ± 0.67abcd	0.00 ± 338.69c	4.26 ± 1.01abcd	1.23 ± 0.29abcd
S1F1	3.23 ± 0.42ab	216.57 ± 215.72ab	4.91 ± 0.65ab	1.41 ± 0.19a
S1F2	3.20 ± 0.18ab	201.63 ± 93.48abc	4.87 ± 0.28ab	1.40 ± 0.08ab
S1F3	2.78 ± 0.06abcd	-12.33 ± 31.98c	4.23 ± 0.10abcd	1.22 ± 0.03abcd
S1F4	3.30 ± 0.11a	254.05 ± 58.19a	5.02 ± 0.17a	1.44 ± 0.05a
S2F0	2.04 ± 0.42de	0.00 ± 44.09c	3.10 ± 0.64de	0.89 ± 0.18de
S2F1	2.18 ± 0.67cde	14.41 ± 69.87bc	3.31 ± 1.02cde	0.95 ± 0.29cde
S2F2	2.91 ± 0.47abcd	90.14 ± 49.05abc	4.42 ± 0.72abcd	1.27 ± 0.21abcd
S2F3	2.48 ± 1.03abcde	46.41 ± 107.49abc	3.78 ± 1.57abcde	1.09 ± 0.45abcde
S2F4	2.79 ± 0.45abcd	77.91 ± 46.97abc	4.24 ± 0.68abcd	1.22 ± 0.20abcd
S3F0	1.99 ± 0.24de	0.00 ± 23.75c	3.03 ± 0.36de	0.87 ± 0.10de
S3F1	2.19 ± 0.44cde	19.93 ± 44.03bc	3.33 ± 0.68cde	0.96 ± 0.19cde
S3F2	3.22 ± 0.39ab	121.84 ± 38.66abc	4.90 ± 0.59ab	1.41 ± 0.17ab
S3F3	2.30 ± 0.34bcde	30.75 ± 33.48bc	3.50 ± 0.51bcde	1.01 ± 0.15bcde
S3F4	3.09 ± 0.46abc	108.67 ± 45.97abc	4.69 ± 0.71abc	1.35 ± 0.20abc
S4F0	1.76 ± 0.46e	0.00 ± 37.02c	2.67 ± 0.70e	0.77 ± 0.20e
S4F1	2.05 ± 0.36de	23.07 ± 29.31bc	3.11 ± 0.55de	0.89 ± 0.16de
S4F2	2.16 ± 0.10cde	32.28 ± 8.21bc	3.28 ± 0.15cde	0.94 ± 0.04cde
S4F3	2.38 ± 0.23abcde	49.93 ± 18.84abc	3.62 ± 0.36abcde	1.04 ± 0.10abcde
S4F4	2.53 ± 0.39abcde	62.46 ± 31.35abc	3.85 ± 0.59abcde	1.11 ± 0.17abcde
CV (%)	18.53	160.21	18.52	18.57

Mean ± standard deviation, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The highest of RAE, the EFE subsidized and non-subsidized ratio in the combination of slope and NPK compound fertilization has shown by the combination of flat slope with fertilizer level 200 kg ha^{-1} which was significantly different from the ten other treatment combinations at RAE value and significantly different from eight other treatment combinations at the EFE subsidized and non-subsidized ratio (Table 5). While the lowest RAE value was indicated by the combination of flat slope with fertilizer level of 150 kg ha^{-1} which was significantly different from the combination of flat slope and fertilizer level of 50 kg ha^{-1} only, the EFE subsidized and non-subsidized ratio was indicated by the combination of mountainous slopes with fertilizer level of 0 kg ha^{-1} and significantly different from ten other treatment combinations. Thus, the combination of a flat slope with a fertilizer level of 100 kg ha^{-1} is the best combination that can be applied by maize farmers. This was in line with the report of Wijaya et al. (2015) that fertilizing urea at 100 kg ha^{-1}, SP-36 at 200 kg ha^{-1} and KCl at 100 kg ha^{-1} showed the highest EFE ratio in both subsidized and non-subsidized fertilizers. However, if farmers will continue to maize cultivating on sloping land, it was recommended to arrive at hilly slopes (15-35%) with fertilizer levels of 100 kg ha^{-1} only.

CONCLUSION

The slope and NPK compound fertilization can increase the maize growths. The best combination in increasing plant height and leaves number was the combination of flat slope and fertilizer level of 100 kg ha^{-1}. The slope and NPK compound fertilization can increase the maize yields. The best combination in accelerating the age of male and female maize flowering, increasing the grain yield was the combination of flat slope and fertilizer level of 100 kg ha^{-1}. While on cob weight was combination of hilly slope and fertilizer level of 100 kg ha^{-1}, whereas on the percentage of cob weight to grain yield was a combination of mountainous slope and fertilizer level of 100 kg ha^{-1}. The slope and NPK compound fertilization can increase the RAE percentage, the EFE subsidized and non-subsidized ratio. The best combination of flat slopes and compound NPK fertilization level of 200 kg ha^{-1} has significantly increase the percentage of RAE, the EFE subsidized and non-subsidized ratio, but relatively equal to the the level of 100 kg ha^{-1}. If farmers will continue to maize cultivating on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg ha^{-1} only.

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ФЕДЕРАЛЬНАЯ СЛУЖБА ПО НАДЗОРУ В СФЕРЕ СВЯЗИ, ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ И МАССОВЫХ КОММУНИКАЦИЙ (РОСКОМНАДЗОР)

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EFFECT OF SLOPES AND COMPOUND NPK FERTILIZER ON GROWTH AND YIELD OF MAIZE LOCAL VARIETIES, RELATIVE AGRONOMIC AND ECONOMIC FERTILIZER EFFECTIVENESS TO INCEPTISOL BUMELA, INDONESIA

Nurdin*
Doctorate Program of Agriculture Science, Brawijaya University, Veteran street 65145 Malang, Indonesia.

Mochtar Lutfi Rayes, Soemarno, Sudarto
Department of Soil Science, Faculty Agriculture, Brawijaya University, Veteran Street 65145 Malang, Indonesia.

Nikmah Musa, Muhajir Dunggio
Department of Agrotechnology, Faculty of Agriculture, Gorontalo State University, Genderal Sudirman Street 96122 Gorontalo, Indonesia

*Email: nurdin@ung.ac.id

ABSTRACT
Maize cultivation has been carried out on the mountainous slopes with high fertilizer inputs, but maize productivity is still low. This study investigates the effect of slope and NPK compound fertilization as well as the best combination of growth and yield of local maize, relative agronomic effectiveness (RAE) percentage and economic fertilizer effectiveness (EFE) ratio in Inceptisol Bumela Indonesia. Slope variations (0-8, 8-15, 15-35, >35%) are combined with compound NPK fertilizer levels (0, 50, 100, 150, 200 kg ha^{-1}) with split plot design. Growth data was recorded for changes in plant height and leaves number from 7 DAP to 42 DAP, while yield and yield components are recorded at harvest. The results showed that slope and NPK compound fertilization can increase the growth and yield of maize plants. The combination of flat slopes and fertilizer level of 100 kg ha^{-1} was the best combination in increasing plant height and the leaves number, accelerate the age of male and female flowering flowers, cob weight, grain yield and percentage of cob weight to grain yields. This combination was also able to increase the percentage of RAE, the ratio of EFE subsidized and non-subsidized. If farmers will continue to cultivate maize on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg ha^{-1} only.

KEY WORDS: Slope, fertilizer, NPK compound, growth, yield, maize.

Maize is an excellent commodity in Gorontalo province of Indonesia. Gorontalo Province maize production until 2018 has reached 1.7 million tons or increased by 9.3% from the previous year with a productivity of 5.0 t ha^{-1} (BPS, 2019) which places Gorontalo Province as one of the largest maize producers in Indonesia (Yunus et al., 2018). Maize was cultivated from generation to generation by local farmers (Ardiani, 2009; Fadhilah, 2013) using maize local varieties. However, since 2002 through the agropolitan programs with maize commodity (Jocom et al., 2009; Grace, 2010), the use of local varieties has changed to maize hybrid and composite varieties, so as the maize local varieties were rarely planted and threatened with extinction.

One of Gorontalo's local germplasm was the Motoro Kiki variety (Zubachtirodin and Kasim, 2012). Motoro Kiki is a Gorontalo maize local variety (Yasin et al., 2007) that aged 70-80 day after planting (DAP), yield potential was 3 t ha^{-1} of grain yield, resistant to downy mildew and leaf rust, and was well planted in the lowlands to the highlands (IAARD, 2009). Maize local has better growth than hybrid and maize composite, but the yield component shows the opposite patterns (Kaihatu and Pesireron, 2016).

Maize cultivation in Gorontalo Province region was very massive and has carried out on upland with a slope of 0% (flat) to mountainous land (slope >35%) which was vulnerable to land degradation. In fact, soil erosion that occurred from the Agropolitan maize planting area reported by Husain et al., (2004) as many as 1,396 t ha^{-1} $year^{-1}$. If this condition was left, it will threaten the sustainability of maize farming. Upland for maize cultivation in Bumela Village was generally on Inceptisol (Indonesian Soil and Agroclimate Research Center Team, 1995). Inceptisol was a relatively young soil and its development was a level above of the Entisols (Rachim, 2007), including having a cambic horizons with a percentage of Na can be exchanged by 15% or more (Soil Survey Staff, 2014). Inceptisol has the potential to be developed (Nursyamsi et al., 2002; Hermawan et al., 2018) because it covers 70 million hectares in Indonesia (Kasno, 2009; Muyassir et al., 2012; Hermawan et al., 2018). However, these soils generally have low soil fertility and organic matter content (Abdurachman et al., 2008; Arviandi et al., 2015). Meanwhile, the high intensity of tillage for maize cultivation has led to a decrease in soil fertility (Lorenz et al., 2000; Husain et al., 2002; Pomalingo and Husain, 2003), so as the maize productivity is low, although fertilizer application exceeds recommendations.

A literature study on the results of the effect of slope and compound NPK fertilization combined with the specific growth and yield of maize local varieties has not been found. While information on the performance of growth and yield of maize local on various slopes combined with the level of NPK compound fertilization is very important for farmers and policy makers, especially in the Gorontalo Province. In fact, maize farmers continue to cultivate on sloping land of >25% with less fertilizer input or exceed the recommended fertilizer levels, so this research was important to done. This study aims to investigate the growth and yield of maize local variety of Motoro Kiki, the relative agronomic effectiveness (RAE) and economic fertilization effectiveness (EFE) on various slopes and NPK compound fertilization to Inceptisol Bumela, Indonesia.

MATERIAL AND METHODS

Site study area

The study was conducted to four months (December 2019 to March 2020) on the toposequence of farmers maize land in Bumela Village, Bilato District, Gorontalo Regency, Gorontalo Province, Indonesia. Specifically geographical, the experimental field was rectangular located at 0°36'11.98"-0°36'11.46" N and 122°40'01.33"-122°40'02.49" E at an altitude of 314 m above sea level (m asl), and 0°36'08.39"-0°36'08.11" N and 122°40'00.31"-122°40'01.45" E with an altitude of 339 m asl.

Table 1-Some soil physico-chemical properties were selected at a depth of 0-30 cm

No	Soil properties	Value	Criterion*
1.	Textures:		
a.	Sand (%)	62.00	Sandy clay
b.	Silt (%)	21.50	
c.	Clay (%)	16.60	
2.	pH (H2O	5.65	Rather sour
3.	Soil organik carbon (%)	0.67	Very low
4.	Total nitrogen (%)	0.07	Very low
5.	P-Bray 1 available (mg ka^{-1})	4.02	Low
6.	Cations exchangeable:		
a.	K^+	0.29	Low
b.	Na^+	2.16	Low
c.	Ca^{2+}	3.86	Low
d.	Mg^+	0.38	Low
7.	Cation exchange capacity (cmol kg^{-1})	8.94	Low
8.	Base saturation (%)	79.88	High
9.	Na saturation (%)	24.27	High

Eviyati and Soleman (2009).

This soil is very dark gray brownish (10YR 3/2), granular of soil structure and sandy clay of texture, cation exchange capacity of 8.94 cmol kg^{-1} and base saturation 79.88%, Na saturation of 24.17% (Table 1). Annual average rainfall of 1,245.90 mm with annual average temperature of 28.02ºC (BWS Sulawesi II, 2019) and potential evapotranspiration of 152.95 mm, so the soil moisture regime was Ustic (106 dry days without humid days) and the soil temperature regime was Isohyperthermic. Based on the morphology, soil physicochemical properties and other properties, the soil in the experimental field was classified as Oxic Humustepts (Soil Survey Staff, 2014).

Research material

The compound fertilizer used was NPK Phonska fertilizer with nutrient content (%) of 15-15-15 and Gorontalo maize local was used Motoro Kiki variety. The land was used upland owned by maize farmers with Inceptisol (Oxic Humustepts) soil type. This upland was used starting from flat (0-8%), undulating (8-15%), hilly (15-35%) and mountainous land (> 35%) on one toposequency.

Field experimentals

The field experimental were designed following a split plot design. Four slope treatments were slope of 0-8% (S1), 8-15% (S2), 15-35% (S3) and slope >35% (S4) as the main plots. While the five NPK compound fertilizer treatments, namely 0 kg ha^{-1} (F0), 50 kg ha^{-1} (F1), 100 kg ha^{-1} (F2), 150 kg ha^{-1} (F3), and the level of 200 kg ha^{-1} (F4) as subplots. Each treatment was repeated three replication, so as 60 treatment plot combinations were obtained. The treatment plot was made 2 x 2 m by smoothing the soil evenly with hoe and shovel. The distance between plots was made 1 m to facilitate accessibility to and from the treatment plot.

Maize was planted with a distance of 20 x 40 cm in the planting hole of 2 maize seeds (December 26, 2019), so as to get 50 plant populations per plot. At the maize age of 7 day after planting (DAP), weed cleansing and thinning into 1 plant per holes. The first fertilization was done (1/2 level of fertilization per treatment) and plant embellishment was followed. Weed cleansing and embellishment was done when growing weeds manually with a hoe. At the maize age of 30 DAP, the second fertilization (the remaining 1/2 level of fertilization per treatment) was continued with plant embellishment. Maintenance continues until the harvest stage. Maize harvesting was done when the physical condition of the maize was dry and yellows (26 March 2020) or ± 90 DAP.

Observation of maize growth variables, including plant height (cm) and leaves number was carried out from plants aged 7 DAP to male flowers (± 42 DAP) on ten selected plants per plot. While the maize yield variables, including age of male and female flowering (DAP) were observed when maize flowers first appeared, the cob weight (t ha^{-1}) was weighed after the maize seeds were separated from the cob, the grain yield (t ha^{-1}) was weighed after the maize seeds were dried under 5 days sun exposure (± 15% moisture content) and the percentage of cob weight to grain yields (%).

Data analysis

NPK compound fertilizer applied, either singly or in combination was tested by relative agronomic effectiveness or RAE (Mackay et al., 1984; Chien, 1996) with the following equation:

$$RAE = \frac{Yt - Yo}{Ys - Yo}\ x\ 100$$

Where: Yt = maize yield on the tested fertilizer (t ha^{-1}), Ys = maize yield standard (t ha^{-1}), and Yo = maize yield on the control treatment (t ha^{-1}). The greater the percentage of RAE, the better the effectiveness of fertilizer relative to agronomic traits. Meanwhile, to find out the fertilizer used has a good economic value, an economic fertilizer effectiveness (EFE) was carried out with the following equation:

$$Ratio\ EFE = \frac{P\ x\ Q}{C}$$

Where: P = price of maize per kg (IDR Kg^{-1}), Q = total yield (kg ha^{-1}), and C = price of fertilizer (IDR Ha^{-1}). If the EFE ratio was >1, the fertilizer tested has good economic value (Saeri and Suwono, 2012; Wijaya et al., 2015).

The price of maize per kg in the study area was IDR 3,500. While the price of Phonska compound NPK fertilizer consists of two, namely NPK Phonska was subsidized by the government at a price of IDR 2,300 and non-subsidized at a price of IDR 8,000. The two forms of NPK fertilizer were used as a comparison material as well as consideration in making the best agronomic and economical NPK compound fertilizer selection decisions. All data obtained were analyzed with ANOVA of split plot design divided into patterns 4^5. If there was a treatment that has a significant effect, then it was continued with the Duncan Multiple Range Test (DMRT) at the test level P >0.05 with the tools of the Statistical Analysis System (SAS) program.

RESULT AND DISCUSSION

Effect of slope and NPK compound fertilizer on maize growth

Slopes and NPK compound fertilization showed has significant effect on the plant height at the age of 14, 21, 28, 35, and 42 DAP, except at the age of 7 DAP in all treatments and at the age of 14 DAP in the treatment of compound NPK fertilizer that has not significantly affected (Table 2).

Table 2-The average of plant height of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Plant Heigh (cm)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	16.37 ± 0.40ns	33.28 ± 1.89ab	79.70 ± 4.31c	95.92 ± 6.48b	137.33 ± 4.49c	180.87 ± 10.48b
S2 (8 – 15%)	16.06 ± 0.38	34.97 ± 1.87b	69.99 ± 4.32b	83.90 ± 8.08a	120.67 ± 11.47ab	160.46 ± 13.22a
S3 (15 – 35%)	16.13 ± 0.40	32.36 ± 0.87a	63.41 ± 2.89a	89.26 ± 3.13a	113.94 ± 3.97a	159.33 ± 8.48a
S4 (>35%)	16.05 ± 0.62	33.02 ± 1.23ab	68.77 ± 2.93b	99.01 ± 5.19b	127.07 ± 7.89b	160.52 ± 9.95a
NPK Compound (F):						
F0 (0 kg ha^{-1})	16.45 ± 0.48ns	34.00 ± 0.65ns	69.80 ± 4.68ab	88.57 ± 11.43a	117.13 ± 12.57a	150.65 ± 10.18a
F1 (50 kg ha^{-1})	15.97 ± 0.17	33.31 ± 2.09	70.32 ± 8.59ab	92.70 ± 6.39ab	124.86 ± 10.99abc	164.78 ± 15.32b
F2 (100 kg ha^{-1})	16.33 ± 0.39	34.33 ± 2.88	72.38 ± 9.92b	96.53 ± 5.90b	131.45 ± 12.71c	173.05 ± 14.53b
F3 (150 kg ha^{-1})	15.97 ± 0.66	32.22 ± 0.71	66.72 ± 5.81a	88.65 ± 7.05a	121.95 ± 8.25ab	168.51 ± 7.38b
F4 (200 kg ha^{-1})	16.02 ± 0.36	33.16 ± 1.20	73.10 ± 6.42b	93.65 ± 10.16ab	128.36 ± 11.33bc	169.47 ± 11.83b
Combinations (SF):						
S1F0	16.35 ± 0.49ns	33.55 ± 3.18abcd	76.55 ± 8.70abc	100.00 ± 17.11abc	134.50 ± 12.45abcd	163.95 ± 12.52cdef
S1F1	15.85 ± 0.92	32.75 ± 0.35abcd	81.75 ± 1.48ab	98.90 ± 1.84abcd	139.80 ± 5.66ab	187.65 ± 9.69ab
S1F2	16.50 ± 0.42	36.40 ± 4.81ab	84.45 ± 6.29a	102.70 ± 3.39ab	143.50 ± 7.07a	190.60 ± 6.93a
S1F3	16.95 ± 3.89	31.65 ± 5.30bcd	73.95 ± 13.79abcd	89.55 ± 18.60bcde	132.00 ± 4.38abcde	178.75 ± 13.22abcd
S1F4	16.20 ± 1.13	32.05 ± 2.90bcd	81.80 ± 4.53ab	88.45 ± 1.63bcde	136.85 ± 4.31abc	183.40 ± 3.54abc
S2F0	16.20 ± 0.00	34.40 ± 5.37abcd	67.45 ± 8.56cdef	73.30 ± 10.89f	107.30 ± 13.01h	139.20 ± 13.15g
S2F1	16.20 ± 1.13	36.35 ± 2.90abc	71.50 ± 3.54bcdef	85.10 ± 3.54cdef	118.10 ± 2.97defgh	158.15 ± 2.76efg
S2F2	16.55 ± 0.21	37.20 ± 3.68a	76.15 ± 1.63abc	95.70 ± 1.27abcde	138.95 ± 16.33ab	174.45 ± 16.19abcde
S2F3	15.60 ± 1.56	32.40 ± 0.42abcd	64.70 ± 1.98cdef	81.10 ± 1.41ef	120.90 ± 7.64cdefgh	165.55 ± 2.05cdef
S2F4	15.75 ± 0.21	34.50 ± 1.13abcd	70.15 ± 6.01bcdef	84.30 ± 3.82def	118.10 ± 10.89defgh	164.95 ± 2.90cdef
S3F0	16.10 ± 0.42	33.35 ± 2.76abcd	66.05 ± 1.48cdef	87.30 ± 0.99cdef	108.50 ± 1.27gh	148.95 ± 4.60fg
S3F1	16.00 ± 0.00	31.55 ± 2.05cd	61.80 ± 10.18ef	89.85 ± 3.89bcde	115.30 ± 3.68efgh	158.40 ± 10.75efg
S3F2	16.55 ± 0.78	31.50 ± 0.99d	62.20 ± 3.54def	88.80 ± 2.97bcde	114.90 ± 2.69efgh	172.05 ± 8.70abcde
S3F3	15.55 ± 1.06	33.15 ± 1.06abcd	60.15 ± 3.32f	86.10 ± 0.28cdef	111.90 ± 0.57fgh	161.45 ± 4.88def
S3F4	16.45 ± 1.06	32.25 ± 2.90bcd	66.85 ± 1.63cdef	94.25 ± 2.76abcde	119.10 ± 0.99defgh	155.80 ± 0.85efg
S4F0	17.15 ± 0.78	34.70 ± 0.57abcd	69.15 ± 3.04cdef	93.70 ± 5.66abcde	118.25 ± 14.07defgh	150.50 ± 7.50fg
S4F1	15.85 ± 0.35	32.60 ± 1.13abcd	66.25 ± 2.62cdef	96.95 ± 5.87abcd	126.25 ± 12.52abcdefg	154.95 ± 1.77efg
S4F2	15.75 ± 0.35	32.25 ± 2.33bcd	66.75 ± 4.17cdef	98.95 ± 5.16abcd	128.45 ± 13.65abcdef	155.10 ± 11.60efg
S4F3	15.80 ± 0.28	31.70 ± 0.42bcd	68.10 ± 5.94cdef	97.85 ± 7.57abcd	123.00 ± 8.91bcdefgh	168.30 ± 7.21bcdef
S4F4	15.70 ± 0.57	33.85 ± 1.48abcd	73.60 ± 3.54abcde	107.60 ± 14.42a	139.40 ± 28.43ab	173.75 ± 27.08abcde
CV (%)	7.18	5.88	6.93	6.75	5.84	5.05

Mean ± standard deviation, DAP: day after planting, ns: not significant, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

This was be fathomed because it was not directly related to the plant physiological aspects, but directly related to soil characteristics. Slopes were closely related to the quantity of soil organic carbon, total N, and enzyme activity by changing the rate of litter

decomposition and soil microbial activity (Nahidan et al., 2015). The highest rate of plant height increase at the age of 28 DAP with an average percentage of plant height increase of 111.05% in all treatments and decreased until the age of 42 DAP. While, the highest rate of plant height increase with an average percentage of plant height increase of 70.56% was indicated by the slope 0% (flat) and NPK compound fertilizer as much as 50 kg ha^{-1}, while the rate of plant height increase was lowest with an average percentage of plant height increase of 58.12% only was shown by the slopes >35% (mountainous) and NPK compound fertilizer as much as 0 kg ha^{-1}.

Apparently, the effect of slopes began to be seen clearly in plant height from the age of 14 DAP to 42 DAP, where the flat slope had a significant effect on plant height and the peak effect of the slope was more pronounced at plant height aged of 35 and 42 DAP, followed by a undulating slope. The position of the slope has a significant effect on the maize growth (Changere and Lal, 1997). Hilly and mountainous slopes will receive more sunlight than undulating and flat slopes, so that decomposition of organic matter and nutrient cycling was better. Humidity is a basic environmental factor in a relatively dry area, so higher humidity at the shady slopes location can lead to better nutrition cycles and higher microbial community activity (Xue et al., 2018). The levels of C-organic, total N, P are available and K can be exchanged at the study site is relatively low (Table 1), so fertilizing action was needed. While the effect of NPK compound fertilizer began to be seen clearly in plant height later on from the age of 21 DAP to 42 DAP, where the fertilizing level of 100 kg ha^{-1} showed the highest plant height from the age of 28 DAP, 35 and 42 DAP, but it was not significantly different from the fertilizer level of 50 kg ha^{-1} and 200 kg ha^{-1} at the age of 21 DAP, 28, 35 and 42 DAP, except with fertilizer levels 0 kg ha^{-1} and 150 kg ha^{-1} were significantly different at the age of 28 DAP and 35 DAP. The NPK fertilization has a significant effect on the agronomic parameters of maize (Achiri et al., 2017). Nitrogen is another important soil nutrient that affects plant growth and water use efficiency (Sardans et al., 2008). The application of Phosphor fertilizer increases the efficient utilization of N fertilizer on the production of maize biomass (Mensah and Mensah, 2016). Potassium is needed for maize growth (Solihin et al., 2019).

The combination of slopes and NPK compound fertilizers began to showing a significant effect on plant height aged of 14 DAP to 42 DAP, while at age of 7 DAP had no significant effect (Table 2). The combination of flat slope (0-8%) to undulating slope (8-15%) with NPK fertilizer compound level of 100 kg ha^{-1} shows the highest plant height at the age of 21 DAP to 42 DAP. While on a combination of hilly slopes (15-35%) and mountainous slopes (35%) with all levels of fertilization was relatively varied. However, if the lands with these slopes will still be used for maize cultivation, then it will be sought only to land with hilly slopes (15-35%) combined with NPK compound fertilizer levels of 100 kg ha^{-1} because plant height reaches of 174.45 cm at age of 42 DAP. At low fertilization rates, the amount of N and K absorbed by plants increases with the amount of fertilizer applied (Niu et al., 2013). Maize plants absorb large amounts of N from the soil at V6 and maximum absorption occurs before silking (Ma' et al., 2003).

The effect of the slope on the leaves number shows the significant effect from the age of 7 DAP to 42 DAP, while the effect of compound NPK fertilization shows the significant effect later starting at age of 21 DAP to 42 DAP (Table 3). The highest rate of leaves number increasing occurred at the age of 14 DAP with an average percentage of leaves number increase of 79.70% in all treatments and decreased until the age of 42 DAP. The rate of increasing the leaves number with an average percentage leaves number increase by 38.16% was indicated by the slopes >35% (mountainous) and NPK compound fertilizer as much as 150 kg ha^{-1}, while the rate of increasing the leaves number with an average the percentage of leaves number increase was 29.94% only, as indicated by the slopes 15-35% (hilly) and NPK compound fertilizer as much as 200 kg ha^{-1}. Leaves number of maize increased significantly as the plants aged with NPK

fertilizing (Titah et al., 2016). Effect of slope on the leaves number at age of 7 DAP shows the highest leaves number on hilly slopes (15-35%) and not significantly different from flat slopes (0-8%) and undulating slopes (8-15%), but significantly different from slopes mountainous (>35%). At the age of 14 DAP, the effect of hilly slopes still shows the highest leaves number and was significantly different from flat slopes and undulating slopes, while those with mountainous slopes are not significantly different. At the age of 21 DAP and 28 DAP, the effect of flat slope has shown the highest leaves number and was significantly different from all slope classes, except at the age of 28 DAP which was only significantly different from hilly slopes. While at the age of 35 DAP and 42 DAP, the effect of mountainous slopes shows the highest leaves number and was not significantly different from flat slopes.

Table 3-The average of number leaves of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Leaves Number (strands)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	3.26 ± 0.12b	5.33 ± 0.09a	8.32 ± 0.38a	9.68 ± 0.52b	10.99 ± 0.23c	12.24 ± 0.38bc
S2 (8 – 15%)	3.22 ± 0.08b	5.78 ± 0.20b	8.00 ± 0.15b	9.40 ± 0.38b	10.49 ± 0.48b	11.70 ± 0.46a
S3 (15 – 35%)	3.34 ± 0.15b	6.02 ± 0.22c	7.91 ± 0.18b	9.07 ± 0.29a	10.22 ± 0.28a	12.02 ± 0.40b
S4 (>35%)	2.99 ± 0.11a	5.83 ± 0.06bc	7.90 ± 0.29b	9.50 ± 0.34b	11.01 ± 0.33c	12.51 ± 0.53c
NPK Compound (F):						
F0 (0 kg ha^{-1})	3.22 ± 0.06ns	5.70 ± 0.32ns	7.73 ± 0.21a	8.88 ± 0.25a	10.22 ± 0.41a	11.43 ± 0.25a
F1 (50 kg ha^{-1})	3.15 ± 0.15	5.87 ± 0.31	8.18 ± 0.55b	9.48 ± 0.54b	10.55 ± 0.54b	12.21 ± 0.51b
F2 (100 kg ha^{-1})	3.23 ± 0.23	5.70 ± 0.20	8.07 ± 0.22b	9.63 ± 0.43b	10.93 ± 0.27c	12.38 ± 0.19b
F3 (150 kg ha^{-1})	3.13 ± 0.21	5.65 ± 0.29	8.06 ± 0.02b	9.51 ± 0.23b	10.87 ± 0.48c	12.33 ± 0.24b
F4 (200 kg ha^{-1})	3.26 ± 0.22	5.77 ± 0.44	8.10 ± 0.15b	9.53 ± 0.28b	10.80 ± 0.42bc	12.21 ± 0.66b
Combinations (SF):						
S1F0	3.30 ± 0.00abc	5.25 ± 0.07e	8.00 ± 0.28cde	9.10 ± 0.42cdef	10.60 ± 0.42abc	11.65 ± 0.64cde
S1F1	3.20 ± 0.14abc	5.45 ± 0.21cde	8.95 ± 0.49a	10.25 ± 1.06a	11.15 ± 0.49ab	12.65 ± 0.49ab
S1F2	3.45 ± 0.21ab	5.40 ± 0.14cde	8.40 ± 0.28b	10.20 ± 0.14ab	11.15 ± 0.64ab	12.40 ± 0.57abc
S1F3	3.20 ± 0.42abc	5.25 ± 0.21e	8.10 ± 0.42cde	9.50 ± 0.28abcde	11.00 ± 0.14ab	12.40 ± 0.57abc
S1F4	3.15 ± 0.21abc	5.30± 0.28de	8.15 ± 0.35bcd	9.35 ± 0.64cdef	11.05 ± 0.49ab	12.10 ± 0.28bcd
S2F0	3.20 ± 0.28abc	5.70 ± 0.14bcde	7.80 ± 0.00efg	8.75 ± 0.21ef	9.95 ± 0.07e	11.15 ± 0.07e
S2F1	3.30 ± 0.14abc	6.10 ± 0.42ab	8.15 ± 0.21bcd	9.45 ± 0.07bcde	10.05 ± 0.07de	11.50 ± 0.14de
S2F2	3.15 ± 0.07abc	5.85 ± 0.21abcd	7.90 ± 0.00def	9.70 ± 0.85abcd	11.05 ± 0.78ab	12.25 ± 1.06bcd
S2F3	3.15 ± 0.21abc	5.65 ± 0.07bcde	8.05 ± 0.07cde	9.50 ± 0.28abcde	10.85 ± 0.07abc	12.10 ± 0.14bcd
S2F4	3.30 ± 0.14abc	5.60 ± 0.14bcde	8.10 ± 0.00cde	9.60 ± 0.57abcd	10.55 ± 0.21bcd	11.50 ± 0.42de
S3F0	3.25 ± 0.49abc	5.95 ± 0.49abc	7.60 ± 0.14g	8.60 ± 0.14f	9.80 ± 0.28e	11.30 ± 0.28e
S3F1	3.15 ± 0.07abc	6.10 ± 0.28ab	8.00 ± 0.28cde	9.00 ± 0.00def	10.15 ± 0.07de	12.20 ± 0.14bcd
S3F2	3.40 ± 0.14ab	5.75 ± 0.35bcde	8.00 ± 0.14cde	9.20 ± 0.00cdef	10.55 ± 0.07bcd	12.25 ± 0.35bcd
S3F3	3.35 ± 0.07abc	5.95 ± 0.21abc	8.05 ± 0.07cde	9.25 ± 0.07cdef	10.25 ± 0.07de	12.20 ± 0.14bcd
S3F4	3.55 ± 0.07a	6.35 ± 0.07a	7.90 ± 0.14def	9.30 ± 0.00cdef	10.35 ± 0.21cde	12.15 ± 0.07bcd
S4F0	3.15 ± 0.07abc	5.90 ± 0.14abc	7.55 ± 0.07g	9.10 ± 0.00cdef	10.55 ± 0.21bcd	11.65 ± 0.49cde
S4F1	2.95 ± 0.07bc	5.85 ± 0.21abcd	7.65 ± 0.07fg	9.25 ± 0.07cdef	10.85 ± 0.07abc	12.50 ± 0.28ab
S4F2	2.95 ± 0.07bc	5.80 ± 0.28abcde	8.00 ± 0.14cde	9.45 ± 0.07bcde	11.00 ± 0.14ab	12.65 ± 0.07ab
S4F3	2.85 ± 0.07c	5.75 ± 0.07bcde	8.05 ± 0.21cde	9.80 ± 0.14abcd	11.40 ± 0.14a	12.65 ± 0.64ab
S4F4	3.05 ± 0.21abc	5.85 ± 0.07abcd	8.25 ± 0.07bc	9.90 ± 0.14abc	11.25 ± 0.21a	13.10 ± 0.28a
CV (%)	6.39	4.01	1.54	3.48	2.32	2.71

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The effect of NPK compound fertilizer on the leaves number at the age of 7 DAP shows the highest leaves number at the fertilizer level of 200 kg ha^{-1}, while at the age of 14 DAP the highest leaves number at the fertilizer level of 50 kg ha^{-1}, although at the two ages it was not significantly different from all fertilization levels. At the age of 21 DAP, NPK compound fertilization shown has significant effect with the highest leaves number at the fertilizer level of 50 kg ha^{-1} and significantly different from the fertilizer level of 0 kg ha^{-1} only. While at the age of 28 DAP to 42 DAP, the effect of compound NPK fertilizer on the most leaves number was indicated by the fertilizer level of 100 kg ha^{-1} and significantly different from the fertilizer level of 0 kg ha^{-1} only, except at age of 35 DAP apart from being significantly different from the level 0 kg ha^{-1} also with a fertilizer level of 50 kg ha^{-1}. The combination of slope and compound NPK fertilizer shows a significant effect on the leaves number starting at age of 7 DAP to 42 DAP (Table 3). The combination of hilly slopes with NPK compound fertilizer of 200 kg ha^{-1} level shows the highest leaves number at the age of 7 DAP to 14 DAP and was significantly different with the combination of mountainous slopes with fertilizer levels of 50, 100 and 150 kg ha^{-1} at age of 7 DAP only, as well as a combination of flat slope and fertilizer level of 0 kg ha^{-1} to 200 kg ha^{-1}, a combination of undulating slopes with fertilizer levels of 0 kg ha^{-1}, 150 and 200 kg ha^{-1}, a combination of hilly and mountainous slopes with levels 100 kg ha^{-1}. While at the age of 21 DAP, the highest leaves number was indicated by a combination of flat slope and 50 kg ha^{-1} fertilizer level that was significantly different from all treatment combinations. The same pattern was also shown by the highest leaves number at the age of 28 DAP on a combination of flat slope and 50 kg ha^{-1} fertilizer level, but significantly different from the twelve other treatment combinations. At the age of 35 DAP, the effect of mountainous slopes with fertilizer level of 150 kga ha^{-1} combination showed the highest leaves number and was significantly different from nine other treatment combinations, whereas at age of 42 DAP the highest leaves number was indicated by a combination of mountainous slopes with a fertilizer level of 200 kg ha^{-1} and significantly different from thirteen other treatment combinations.

Effect of slopes and NPK compound fertilizer on maize yields

The effects of slopes and compound NKP fertilizers show a significant effect on all yield components (Table 4). On the flat slope (0-8%), the male flowers (42.21 DAP) and the female maize flowers (47.64 DAP) were the most significantly different from the other slopes, while on the hilly slopes (15-35%) the male flowers were the longest (45.84 DAP) and female flowers (49.31 DAP). The highest of cob weight and grain yields on the flat slope (0-8%) that it was significantly different from other slopes, except that the cob weight was not significantly different from other slopes. The highest of cob weight percentage ton grain yield was shown by mountainous slopes (>35%) and has not significantly different from flat slopes. The slope position also has a significant effect on maize yield (Changere and Lal, 1997), as the slope and organic fertilizer have a significant and very significant effect on potato yield (Wati et al., 2014). The 10-22% lower content of organic matter, nitrogen, and phosphorus on the lower middle slope is associated with a decrease in maize yield of 27% compared to the position of the upper middle slope (Wezel et al., 2002).

The effect of NPK compound fertilizer on the age of male and female maize flowers was the fastest out (44.87 DAP and 48.22 DAP respectively) and the highest cob weight was shown by the fertilizer level of 100 kg ha^{-1} which was significantly different with the level of fertilizer 0 kg ha^{-1} only. While the highest of grain yields hass shown by the fertilizer level of 200 kg ha^{-1} but not significantly different from the fertilizer level of 100 kg ha^{-1}, whereas the highest of cob weight percentage to grain yield was indicated by the level of 50 kg ha^{-1} and significantly different with the level of 0 kg ha^{-1} and 200 kg ha^{-1} only. The NPK fertilization has a significant effect on maize yield parameters (Achiri et al., 2017). Flowering time can often be accelerated 3-10 days by application of NPK fertilizer (Gumeleng, 2003). Female maize flowering were most quickly obtained at the fertilizer level of 250 kg ha^{-1} N, 100 kg ha^{-1} P and 75 kg ha^{-1} K whereas the latest were obtained at 0 kg ha^{-1} level (Nurdin et al., 2009). Phosphor is able to increase the photosynthesis process which will further influence the increase in dry weight of plants (Minardi, 2002).

The combination of slope and NPK compound fertilizer shows a significant effect on all yield components (Table 4). The combination of flat slope with NPK compound fertilizer level of 100 kg ha^{-1} shows the age of male and female maize flowering fastest and has significantly different from the ten slope combinations and fertilizer level at age of male maize flowering, and significantly different from the eight slope combinations and other fertilizer levels at age of female maize flowering. Meanwhile, the highest of cob weight was shown by a combination of hilly slopes and fertilizer level of 100 kg ha^{-1} which was significantly different from four other treatment combinations only. The highest of grain yiled was shown by the combination of flat slope and fertilizer level of 200 kg ha^{-1}, but it was significantly different from only eight other treatment combinations. Whereas the highest of cob weight percentage to grain yiled was shown by the combination of mountainous slopes with a fertilizer level of 100 kga ha^{-1} and significantly different from five other treatment combinations only. The best combination of slope and NPK compound fertilizer on maize yield parameters was flat slope with fertilizer level of 100 kg ha^{-1}. This was in line with the report of Ngosong et al., (2019) that N fertilizing between 50 and 100 kg N ha^{-1} was optimal for maize production in Cameroon's volcanic soil.

Table 4-The average of component yield of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia.

Treatments	Male Flowering Age (DAP)	Female Flowering Age (DAP)	Cob Weight (t ha^{-1})	Grain Yields (t ha^{-1})	Percentage of Cob Weight to Grain Yields (%)
Slopes (S):					
S1 (0 – 8%)	44.21 ± 0.84a	47.64 ± 0.70a	1.78 ± 0.27ns	3.06 ± 0.25c	20.43 ± 2.39a
S2 (8 – 15%)	45.53 ± 0.49b	48.92 ± 0.70b	1.51 ± 0.37	2.48 ± 0.37ab	22.49 ± 2.93ab
S3 (15 – 35%)	45.84 ± 0.54b	49.31 ± 0.74b	1.70 ± 0.31	2.56 ± 0.47b	24.27 ± 3.37b
S4 (>35%)	45.53 ± 0.77b	48.82 ± 0.86b	1.55 ± 0.29	2.18 ± 0.33a	25.31 ± 4.14b
NPK Compound (F):					
F0 (0 kg ha^{-1})	45.92 ± 1.17b	49.57 ± 1.24a	1.19 ± 0.24a	2.15 ± 0.46a	20.36 ± 2.20a
F1 (50 kg ha^{-1})	45.01 ± 1.01ab	48.42 ± 0.85b	1.65 ± 0.31b	2.41 ± 0.49a	26.37 ± 3.77b
F2 (100 kg ha^{-1})	44.87 ± 1.14a	48.22 ± 1.15b	1.81 ± 0.26b	2.87 ± 0.50bc	23.03 ± 5.23ab
F3 (150 kg ha^{-1})	45.25 ± 0.57ab	48.59 ± 0.58b	1.74 ± 0.18b	2.49 ± 0.21ab	24.19 ± 1.49ab
F4 (200 kg ha^{-1})	45.34 ± 0.43ab	48.57 ± 0.49b	1.78 ± 0.12b	2.93 ± 0.34c	21.66 ± 1.62a
Combinations (SF):					
S1F0	44.25 ± 1.63bcd	47.75 ± 1.81bcd	1.48 ± 0.42abcde	2.80 ± 0.67abcd	19.71 ± 0.85cde
S1F1	43.50 ± 0.28cd	47.17 ± 0.28cd	2.08 ± 0.21ab	3.23 ± 0.42ab	21.21 ± 3.68abcde
S1F2	43.35 ± 0.12d	46.80 ± 0.05d	1.49 ± 0.68abcde	3.20 ± 0.18ab	16.94 ± 7.83e
S1F3	44.52 ± 1.06bcd	47.86 ± 0.94bcd	1.87 ± 0.32abc	2.78 ± 0.06abcd	23.50 ± 3.25abcde
S1F4	45.42 ± 0.49abcd	48.61 ± 0.54abcd	1.95 ± 0.03abc	3.30 ± 0.11a	20.77 ± 1.29abcde
S2F0	45.98 ± 1.15ab	49.85 ± 1.01ab	0.92 ± 0.13e	2.04 ± 0.42de	18.08 ± 5.14de
S2F1	45.67 ± 0.71ab	48.91 ± 0.68abc	1.35 ± 0.25bcde	2.18 ± 0.67cde	25.93 ± 1.17abcde
S2F2	44.71 ± 0.68abcd	47.90 ± 0.61bcd	1.77 ± 0.05abcd	2.91 ± 0.47abcd	23.06 ± 5.15abcde
S2F3	45.48 ± 0.45abc	48.83 ± 0.33abcd	1.76 ± 0.44abcd	2.48 ± 1.03abcde	23.83 ± 5.83abcde
S2F4	45.80 ± 0.90ab	49.08 ± 0.82abc	1.73 ± 0.47abcd	2.79 ± 0.45abcd	21.58 ± 0.97abcde
S3F0	46.65 ± 0.26a	50.46 ± 0.38a	1.28 ± 0.10cde	1.99 ± 0.24de	23.33 ± 1.86abcde
S3F1	45.30 ± 1.79abcd	48.65 ± 1.72abcd	1.59 ± 0.14abcde	2.19 ± 0.44cde	28.87 ± 3.52abc
S3F2	46.00 ± 0.57ab	49.51 ± 0.73ab	2.13 ± 0.02a	3.22 ± 0.39ab	22.42 ± 2.67abcde
S3F3	45.86 ± 0.94ab	49.23 ± 0.94abc	1.83 ± 0.01abcd	2.30 ± 0.34bcde	26.38 ± 3.49abcd
S3F4	45.38 ± 0.07abcd	48.70 ± 0.00abcd	1.67 ± 0.17abcd	3.09 ± 0.46abc	20.32 ± 0.93bcde
S4F0	46.80 ± 0.42a	50.20 ± 0.33a	1.09 ± 0.38de	1.76 ± 0.46e	20.30 ± 0.78bcde
S4F1	45.55 ± 0.49abc	48.95 ± 0.26abc	1.57 ± 0.27abcde	2.05 ± 0.36de	29.48 ± 0.81ab
S4F2	45.43 ± 0.52abc	48.65 ± 0.45abcd	1.83± 0.09abcd	2.16 ± 0.10cde	29.71 ± 3.46a
S4F3	45.11 ± 0.68abcd	48.41 ± 0.59abcd	1.48 ± 0.12abcde	2.38 ± 0.23abcde	23.08 ± 1.32abcde
S4F4	44.75 ± 1.58abcd	47.90 ± 1.84bcd	1.77 ± 0.07abcd	2.53 ± 0.39abcde	23.96 ± 3.55abcde
CV (%)	1.88	1.77	18.54	18.53	16.34

Mean ± standard deviation, DAP: day after planting, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

Relative agronomic and economic fertilization effectiveness

The highest of relative agronomic effectiveness (RAE) values, the ratio of economic fertilization effectiveness (EFE) with subsidized fertilizer and non-subsidized was shown by flat slopes (0-8%) which differ significantly by undulating slopes (8-15%) and mountainous slopes (>35%) on RAE, significantly different from all slopes in the EFE subsidized and non-subsidized ratio (Table 5), in other to the distribution was obtained following the RAE pattern S1> S3> S2> S4. Provision of standard or recommended of NPK Fertilizers (300 kg ha^{-1} NPK+250 kg ha^{-1} Urea) shows a higher RAE value (100) than other fertilizer doses to maize plants (Kasno, 2010; Wijaya et al., 2015; Erselia et al., 2017; Subandi et al., 2017), in sugarcane (Zulkarnain et al., 2017). Furthermore, the highest of the RAE value, EFE subsidized and non-subsidized ratio with NPK compound fertilization was shown by fertilizer level of 200 kg ha^{-1} which was not significantly different with fertilizer level of 50 kg ha^{-1} and 100 kg ha^{-1} at RAE, and has not significantly different only with the level of 100 kg ha^{-1} in the EFE subsidized and non-subsidized ratio, so as the distribution was obtained following the pattern F4> F2> F3> F1> F0.

Table 5-Relative agronomic effectiveness (RAE) and economic fertilizer effectiveness (EFE) of maize yields with NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Grain Yields (t ha^{-1})	RAE (%)	Ratio of EFE (Subsidized Fertilizer)	Ratio of EFE (Non-Subsidized Fertilizer)
Slopes (S):				
S1 (0 – 8%)	3.06 ± 0.25c	131.98 ± 127.63a	4.66 ± 0.38a	1.34 ± 0.11a
S2 (8 – 15%)	2.48 ± 0.37ab	45.77 ± 38.99b	3.77 ± 0.57bc	1.08 ± 0.16bc
S3 (15 – 35%)	2.56 ± 0.47b	56.24 ± 55.19ab	3.89 ± 0.85b	1.12 ± 0.24b
S4 (>35%)	2.18 ± 0.33a	33.55 ± 24.19b	3.31 ± 0.46c	0.95 ± 0.13c
NPK Compound (F):				
F0 (0 kg ha^{-1})	2.15 ± 0.46a	0.00 ± 0.00c	3.26 ± 0.69c	0.94 ± 0.20c
F1 (50 kg ha^{-1})	2.41 ± 0.49a	68.50 ± 98.78abc	3.66 ± 0.84c	1.05 ± 0.24c
F2 (100 kg ha^{-1})	2.87 ± 0.50bc	111.47 ± 70.62ab	4.36 ± 0.75ab	1.26 ± 0.22ab
F3 (150 kg ha^{-1})	2.49 ± 0.21ab	28.69 ± 28.59bc	3.79 ± 0.32bc	1.09 ± 0.09bc
F4 (200 kg ha^{-1})	2.93 ± 0.34c	125.77 ± 87.65a	4.45 ± 0.51a	1.28 ± 0.15a
Combinations (SF):				
S1F0	2.80 ± 0.67abcd	0.00 ± 338.69c	4.26 ± 1.01abcd	1.23 ± 0.29abcd
S1F1	3.23 ± 0.42ab	216.57 ± 215.72ab	4.91 ± 0.65ab	1.41 ± 0.19a
S1F2	3.20 ± 0.18ab	201.63 ± 93.48abc	4.87 ± 0.28ab	1.40 ± 0.08ab
S1F3	2.78 ± 0.06abcd	-12.33 ± 31.98c	4.23 ± 0.10abcd	1.22 ± 0.03abcd
S1F4	3.30 ± 0.11a	254.05 ± 58.19a	5.02 ± 0.17a	1.44 ± 0.05a
S2F0	2.04 ± 0.42de	0.00 ± 44.09c	3.10 ± 0.64de	0.89 ± 0.18de
S2F1	2.18 ± 0.67cde	14.41 ± 69.87bc	3.31 ± 1.02cde	0.95 ± 0.29cde
S2F2	2.91 ± 0.47abcd	90.14 ± 49.05abc	4.42 ± 0.72abcd	1.27 ± 0.21abcd
S2F3	2.48 ± 1.03abcde	46.41 ± 107.49abc	3.78 ± 1.57abcde	1.09 ± 0.45abcde
S2F4	2.79 ± 0.45abcd	77.91 ± 46.97abc	4.24 ± 0.68abcd	1.22 ± 0.20abcd
S3F0	1.99 ± 0.24de	0.00 ± 23.75c	3.03 ± 0.36de	0.87 ± 0.10de
S3F1	2.19 ± 0.44cde	19.93 ± 44.03bc	3.33 ± 0.68cde	0.96 ± 0.19cde
S3F2	3.22 ± 0.39ab	121.84 ± 38.66abc	4.90 ± 0.59ab	1.41 ± 0.17ab
S3F3	2.30 ± 0.34bcde	30.75 ± 33.48bc	3.50 ± 0.51bcde	1.01 ± 0.15bcde
S3F4	3.09 ± 0.46abc	108.67 ± 45.97abc	4.69 ± 0.71abc	1.35 ± 0.20abc
S4F0	1.76 ± 0.46e	0.00 ± 37.02c	2.67 ± 0.70e	0.77 ± 0.20e
S4F1	2.05 ± 0.36de	23.07 ± 29.31bc	3.11 ± 0.55de	0.89 ± 0.16de
S4F2	2.16 ± 0.10cde	32.28 ± 8.21bc	3.28 ± 0.15cde	0.94 ± 0.04cde
S4F3	2.38 ± 0.23abcde	49.93 ± 18.84abc	3.62 ± 0.36abcde	1.04 ± 0.10abcde
S4F4	2.53 ± 0.39abcde	62.46 ± 31.35abc	3.85 ± 0.59abcde	1.11 ± 0.17abcde
CV (%)	18.53	160.21	18.52	18.57

Mean ± standard deviation, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The highest of RAE, the EFE subsidized and non-subsidized ratio in the combination of slope and NPK compound fertilization has shown by the combination of flat slope with fertilizer level 200 kg ha^{-1} which was significantly different from the ten other treatment combinations at RAE value and significantly different from eight other treatment combinations at the EFE subsidized and non-subsidized ratio (Table 5). While the lowest RAE value was indicated by the combination of flat slope with fertilizer level of 150 kg ha^{-1} which was significantly different from the combination of flat slope and fertilizer level of 50 kg ha^{-1} only, the EFE subsidized and non-subsidized ratio was indicated by the combination of mountainous slopes with fertilizer level of 0 kg ha^{-1} and significantly different from ten other treatment combinations. Thus, the combination of a flat slope with a fertilizer level of 100 kg ha^{-1} is the best combination that can be applied by maize farmers. This was in line with the report of Wijaya et al. (2015) that fertilizing urea at 100 kg ha^{-1}, SP-36 at 200 kg ha^{-1} and KCl at 100 kg ha^{-1} showed the highest EFE ratio in both subsidized and non-subsidized fertilizers. However, if farmers will continue to maize cultivating on sloping land, it was recommended to arrive at hilly slopes (15-35%) with fertilizer levels of 100 kg ha^{-1} only.

CONCLUSION

The slope and NPK compound fertilization can increase the maize growths. The best combination in increasing plant height and leaves number was the combination of flat slope and fertilizer level of 100 kg ha^{-1}. The slope and NPK compound fertilization can increase the maize yields. The best combination in accelerating the age of male and female maize flowering, increasing the grain yield was the combination of flat slope and fertilizer level of 100 kg ha^{-1}. While on cob weight was combination of hilly slope and fertilizer level of 100 kg ha^{-1}, whereas on the percentage of cob weight to grain yield was a combination of mountainous slope and fertilizer level of 100 kg ha^{-1}. The slope and NPK compound fertilization can increase the RAE percentage, the EFE subsidized and non-subsidized ratio. The best combination of flat slopes and compound NPK fertilization level of 200 kg ha^{-1} has significantly increase the percentage of RAE, the EFE subsidized and non-subsidized ratio, but relatively equal to the the level of 100 kg ha^{-1}. If farmers will continue to maize cultivating on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg ha^{-1} only.

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ФЕДЕРАЛЬНАЯ СЛУЖБА ПО НАДЗОРУ
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By this letter confirmed that paper titled «EFFECT OF SLOPES AND COMPOUND NPK FERTILIZER ON GROWTH AND YIELD OF MAIZE LOCAL VARIETIES, RELATIVE AGRONOMIC AND ECONOMIC FERTILIZER EFFECTIVENESS TO INCEPTISOL BUMELA, INDONESIA» (authors: *Nurdin, Rayes M.L., Soemarno, Sudarto, Musa N., Dunggio M.*) submitted by *Nurdin* (Doctorate Program of Agricultural Science, University of Brawijaya, Malang, Indonesia) has been accepted for publishing in Russian Journal of Agricultural and Socio-Economic Sciences (RJOAS), issue 6(102) of June 2020.

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EFFECT OF SLOPES AND COMPOUND NPK FERTILIZER ON GROWTH AND YIELD OF MAIZE LOCAL VARIETIES, RELATIVE AGRONOMIC AND ECONOMIC FERTILIZER EFFECTIVENESS TO INCEPTISOL BUMELA, INDONESIA

Nurdin*
Doctorate Program of Agricultural Science, University of Brawijaya, Malang, Indonesia

Rayes Mochtar Lutfi, **Soemarno**, **Sudarto**
Department of Soil Science, Faculty of Agriculture, University of Brawijaya, Malang, Indonesia

Musa Nikmah, **Dunggio Muhajir**
Department of Agrotechnology, Faculty of Agriculture, Gorontalo State University, Gorontalo, Indonesia

*E-mail: nurdin@ung.ac.id

ABSTRACT
Maize cultivation has been carried out on the mountainous slopes with high fertilizer inputs, but maize productivity is still low. This study investigates the effect of slope and NPK compound fertilization as well as the best combination of growth and yield of local maize, relative agronomic effectiveness (RAE) percentage and economic fertilizer effectiveness (EFE) ratio in Inceptisol Bumela Indonesia. Slope variations (0-8, 8-15, 15-35, >35%) are combined with compound NPK fertilizer levels (0, 50, 100, 150, 200 kg ha^{-1}) with split plot design. Growth data was recorded for changes in plant height and leaves number from 7 DAP to 42 DAP, while yield and yield components are recorded at harvest. The results showed that slope and NPK compound fertilization can increase the growth and yield of maize plants. The combination of flat slopes and fertilizer level of 100 kg ha^{-1} was the best combination in increasing plant height and the leaves number, accelerate the age of male and female flowering flowers, cob weight, grain yield and percentage of cob weight to grain yields. This combination was also able to increase the percentage of RAE, the ratio of EFE subsidized and non-subsidized. If farmers will continue to cultivate maize on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg ha^{-1} only.

KEY WORDS
Slope, fertilizer, NPK compound, growth, yield, maize.

Maize is an excellent commodity in Gorontalo province of Indonesia. Gorontalo Province maize production until 2018 has reached 1.7 million tons or increased by 9.3% from the previous year with a productivity of 5.0 t ha^{-1} (BPS, 2019) which places Gorontalo Province as one of the largest maize producers in Indonesia (Yunus et al., 2018). Maize was cultivated from generation to generation by local farmers (Ardiani, 2009; Fadhilah, 2013) using maize local varieties. However, since 2002 through the agropolitan programs with maize commodity (Jocom et al., 2009; Grace, 2010), the use of local varieties has changed to maize hybrid and composite varieties, so as the maize local varieties were rarely planted and threatened with extinction.

One of Gorontalo's local germplasm was the Motoro Kiki variety (Zubachtirodin and Kasim, 2012). Motoro Kiki is a Gorontalo maize local variety (Yasin et al., 2007) that aged 70-80 day after planting (DAP), yield potential was 3 t ha^{-1} of grain yield, resistant to downy mildew and leaf rust, and was well planted in the lowlands to the highlands (IAARD, 2009). Maize local has better growth than hybrid and maize composite, but the yield component shows the opposite patterns (Kaihatu and Pesireron, 2016).

Maize cultivation in Gorontalo Province region was very massive and has carried out on upland with a slope of 0% (flat) to mountainous land (slope >35%) which was vulnerable to land degradation. In fact, soil erosion that occurred from the Agropolitan maize planting area reported by Husain et al., (2004) as many as 1,396 t ha^{-1} $year^{-1}$. If this condition was left, it will threaten the sustainability of maize farming. Upland for maize cultivation in Bumela Village was generally on Inceptisol (Indonesian Soil and Agroclimate Research Center Team, 1995). Inceptisol was a relatively young soil and its development was a level above of the Entisols (Rachim, 2007), including having a cambic horizons with a percentage of Na can be exchanged by 15% or more (Soil Survey Staff, 2014). Inceptisol has the potential to be developed (Nursyamsi et al., 2002; Hermawan et al., 2018) because it covers 70 million hectares in Indonesia (Kasno, 2009; Muyassir et al., 2012; Hermawan et al., 2018). However, these soils generally have low soil fertility and organic matter content (Abdurachman et al., 2008; Arviandi et al., 2015). Meanwhile, the high intensity of tillage for maize cultivation has led to a decrease in soil fertility (Lorenz et al., 2000; Husain et al., 2002; Pomalingo and Husain, 2003), so as the maize productivity is low, although fertilizer application exceeds recommendations.

A literature study on the results of the effect of slope and compound NPK fertilization combined with the specific growth and yield of maize local varieties has not been found. While information on the performance of growth and yield of maize local on various slopes combined with the level of NPK compound fertilization is very important for farmers and policy makers, especially in the Gorontalo Province. In fact, maize farmers continue to cultivate on sloping land of >25% with less fertilizer input or exceed the recommended fertilizer levels, so this research was important to done. This study aims to investigate the growth and yield of maize local variety of Motoro Kiki, the relative agronomic effectiveness (RAE) and economic fertilization effectiveness (EFE) on various slopes and NPK compound fertilization to Inceptisol Bumela, Indonesia.

MATERIALS AND METHODS OF RESEARCH

The study was conducted to four months (December 2019 to March 2020) on the toposequence of farmers maize land in Bumela Village, Bilato District, Gorontalo Regency, Gorontalo Province, Indonesia. Specifically geographical, the experimental field was rectangular located at 0°36'11.98"-0°36'11.46" N and 122°40'01.33"-122°40'02.49" E at an altitude of 314 m above sea level (m asl), and 0°36'08.39"-0°36'08.11" N and 122°40'00.31"-122°40'01.45" E with an altitude of 339 m asl.

Table 1 – Some soil physico-chemical properties were selected at a depth of 0-30 cm

No	Soil properties	Value	Criterion*
1.	Textures:		
a.	Sand (%)	62.00	Sandy clay
b.	Silt (%)	21.50	
c.	Clay (%)	16.60	
2.	pH (H2O	5.65	Rather sour
3.	Soil organic carbon (%)	0.67	Very low
4.	Total nitrogen (%)	0.07	Very low
5.	P-Bray 1 available (mg ka^{-1})	4.02	Low
6.	Cations exchangeable:		
a.	K^+	0.29	Low
b.	Na^+	2.16	Low
c.	Ca^{2+}	3.86	Low
d.	Mg^+	0.38	Low
7.	Cation exchange capacity (cmol kg^{-1})	8.94	Low
8.	Base saturation (%)	79.88	High
9.	Na saturation (%)	24.27	High

Source: Eviyati and Soleman (2009).

This soil is very dark gray brownish (10YR 3/2), granular of soil structure and sandy clay of texture, cation exchange capacity of 8.94 cmol kg^{-1} and base saturation 79.88%, Na saturation of 24.17% (Table 1). Annual average rainfall of 1,245.90 mm with annual average temperature of 28.02ºC (BWS Sulawesi II, 2019) and potential evapotranspiration of 152.95 mm, so the soil moisture regime was Ustic (106 dry days without humid days) and the soil temperature regime was Isohyperthermic. Based on the morphology, soil physicochemical properties and other properties, the soil in the experimental field was classified as Oxic Humustepts (Soil Survey Staff, 2014).

The compound fertilizer used was NPK Phonska fertilizer with nutrient content (%) of 15-15-15 and Gorontalo maize local was used Motoro Kiki variety. The land was used upland owned by maize farmers with Inceptisol (Oxic Humustepts) soil type. This upland was used starting from flat (0-8%), undulating (8-15%), hilly (15-35%) and mountainous land (> 35%) on one toposequency.

The field experimental were designed following a split plot design. Four slope treatments were slope of 0-8% (S1), 8-15% (S2), 15-35% (S3) and slope >35% (S4) as the main plots. While the five NPK compound fertilizer treatments, namely 0 kg ha^{-1} (F0), 50 kg ha^{-1} (F1), 100 kg ha^{-1} (F2), 150 kg ha^{-1} (F3), and the level of 200 kg ha^{-1} (F4) as subplots. Each treatment was repeated three replication, so as 60 treatment plot combinations were obtained. The treatment plot was made 2 x 2 m by smoothing the soil evenly with hoe and shovel. The distance between plots was made 1 m to facilitate accessibility to and from the treatment plot.

Maize was planted with a distance of 20 x 40 cm in the planting hole of 2 maize seeds (December 26, 2019), so as to get 50 plant populations per plot. At the maize age of 7 day after planting (DAP), weed cleansing and thinning into 1 plant per holes. The first fertilization was done (1/2 level of fertilization per treatment) and plant embellishment was followed. Weed cleansing and embellishment was done when growing weeds manually with a hoe. At the maize age of 30 DAP, the second fertilization (the remaining 1/2 level of fertilization per treatment) was continued with plant embellishment. Maintenance continues until the harvest stage. Maize harvesting was done when the physical condition of the maize was dry and yellows (26 March 2020) or ± 90 DAP.

Observation of maize growth variables, including plant height (cm) and leaves number was carried out from plants aged 7 DAP to male flowers (± 42 DAP) on ten selected plants per plot. While the maize yield variables, including age of male and female flowering (DAP) were observed when maize flowers first appeared, the cob weight (t ha^{-1}) was weighed after the maize seeds were separated from the cob, the grain yield (t ha^{-1}) was weighed after the maize seeds were dried under 5 days sun exposure (± 15% moisture content) and the percentage of cob weight to grain yields (%).

NPK compound fertilizer applied, either singly or in combination was tested by relative agronomic effectiveness or RAE (Mackay et al., 1984; Chien, 1996) with the following equation:

$$RAE = \frac{Yt - Yo}{Ys - Yo} \; x \; 100$$

Where: Yt = maize yield on the tested fertilizer (t ha^{-1}), Ys = maize yield standard (t ha^{-1}), and Yo = maize yield on the control treatment (t ha^{-1}). The greater the percentage of RAE, the better the effectiveness of fertilizer relative to agronomic traits. Meanwhile, to find out the fertilizer used has a good economic value, an economic fertilizer effectiveness (EFE) was carried out with the following equation:

$$Ratio\ EFE = \frac{P\ x\ Q}{C}$$

Where: P = price of maize per kg (IDR Kg^{-1}), Q = total yield (kg ha^{-1}), and C = price of fertilizer (IDR Ha^{-1}). If the EFE ratio was >1, the fertilizer tested has good economic value (Saeri and Suwono, 2012; Wijaya et al., 2015).

The price of maize per kg in the study area was IDR 3,500. While the price of Phonska compound NPK fertilizer consists of two, namely NPK Phonska was subsidized by the government at a price of IDR 2,300 and non-subsidized at a price of IDR 8,000. The two forms of NPK fertilizer were used as a comparison material as well as consideration in making the best agronomic and economical NPK compound fertilizer selection decisions. All data obtained were analyzed with ANOVA of split plot design divided into patterns 4^5. If there was a treatment that has a significant effect, then it was continued with the Duncan Multiple Range Test (DMRT) at the test level P >0.05 with the tools of the Statistical Analysis System (SAS) program.

RESULTS AND DISCUSSION

Effect of slope and NPK compound fertilizer on maize growth. Slopes and NPK compound fertilization showed has significant effect on the plant height at the age of 14, 21, 28, 35, and 42 DAP, except at the age of 7 DAP in all treatments and at the age of 14 DAP in the treatment of compound NPK fertilizer that has not significantly affected (Table 2).

Table 2 – The average of plant height of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Plant Heigh (cm)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	16.37 ± 0.40ns	33.28 ± 1.89ab	79.70 ± 4.31c	95.92 ± 6.48b	137.33 ± 4.49c	180.87 ± 10.48b
S2 (8 – 15%)	16.06 ± 0.38	34.97 ± 1.87b	69.99 ± 4.32b	83.90 ± 8.08a	120.67 ± 11.47ab	160.46 ± 13.22a
S3 (15 – 35%)	16.13 ± 0.40	32.36 ± 0.87a	63.41 ± 2.89a	89.26 ± 3.13a	113.94 ± 3.97a	159.33 ± 8.48a
S4 (>35%)	16.05 ± 0.62	33.02 ± 1.23ab	68.77 ± 2.93b	99.01 ± 5.19b	127.07 ± 7.89b	160.52 ± 9.95a
NPK Compound (F):						
F0 (0 kg ha^{-1})	16.45 ± 0.48ns	34.00 ± 0.65ns	69.80 ± 4.68ab	88.57 ± 11.43a	117.13 ± 12.57a	150.65 ± 10.18a
F1 (50 kg ha^{-1})	15.97 ± 0.17	33.31 ± 2.09	70.32 ± 8.59ab	92.70 ± 6.39ab	124.86 ± 10.99abc	164.78 ± 15.32b
F2 (100 kg ha^{-1})	16.33 ± 0.39	34.33 ± 2.88	72.38 ± 9.92b	96.53 ± 5.90b	131.45 ± 12.71c	173.05 ± 14.53b
F3 (150 kg ha^{-1})	15.97 ± 0.66	32.22 ± 0.71	66.72 ± 5.81a	88.65 ± 7.05a	121.95 ± 8.25ab	168.51 ± 7.38b
F4 (200 kg ha^{-1})	16.02 ± 0.36	33.16 ± 1.20	73.10 ± 6.42b	93.65 ± 10.16ab	128.36 ± 11.33bc	169.47 ± 11.83b
Combinations (SF):						
S1F0	16.35 ± 0.49ns	33.55 ± 3.18abcd	76.55 ± 8.70abc	100.00 ± 17.11abc	134.50 ± 12.45abcd	163.95 ± 12.52cdef
S1F1	15.85 ± 0.92	32.75 ± 0.35abcd	81.75 ± 1.48ab	98.90 ± 1.84abcd	139.80 ± 5.66ab	187.65 ± 9.69ab
S1F2	16.50 ± 0.42	36.40 ± 4.81ab	84.45 ± 6.29a	102.70 ± 3.39ab	143.50 ± 7.07a	190.60 ± 6.93a
S1F3	16.95 ± 3.89	31.65 ± 5.30bcd	73.95 ± 13.79abcd	89.55 ± 18.60bcde	132.00 ± 4.38abcde	178.75 ± 13.22abcd
S1F4	16.20 ± 1.13	32.05 ± 2.90bcd	81.80 ± 4.53ab	88.45 ± 1.63bcde	136.85 ± 4.31abc	183.40 ± 3.54abc
S2F0	16.20 ± 0.00	34.40 ± 5.37abcd	67.45 ± 8.56cdef	73.30 ± 10.89f	107.30 ± 13.01h	139.20 ± 13.15g
S2F1	16.20 ± 1.13	36.35 ± 2.90abc	71.50 ± 3.54bcdef	85.10 ± 3.54cdef	118.10 ± 2.97defgh	158.15 ± 2.76efg
S2F2	16.55 ± 0.21	37.20 ± 3.68a	76.15 ± 1.63abc	95.70 ± 1.27abcde	138.95 ± 16.33ab	174.45 ± 16.19abcde
S2F3	15.60 ± 1.56	32.40 ± 0.42abcd	64.70 ± 1.98cdef	81.10 ± 1.41ef	120.90 ± 7.64cdefgh	165.55 ± 2.05cdef
S2F4	15.75 ± 0.21	34.50 ± 1.13abcd	70.15 ± 6.01bcdef	84.30 ± 3.82def	118.10 ± 10.89defgh	164.95 ± 2.90cdef
S3F0	16.10 ± 0.42	33.35 ± 2.76abcd	66.05 ± 1.48cdef	87.30 ± 0.99cdef	108.50 ± 1.27gh	148.95 ± 4.60fg
S3F1	16.00 ± 0.00	31.55 ± 2.05cd	61.80 ± 10.18ef	89.85 ± 3.89bcde	115.30 ± 3.68efgh	158.40 ± 10.75efg
S3F2	16.55 ± 0.78	31.50 ± 0.99d	62.20 ± 3.54def	88.80 ± 2.97bcde	114.90 ± 2.69efgh	172.05 ± 8.70abcde
S3F3	15.55 ± 1.06	33.15 ± 1.06abcd	60.15 ± 3.32f	86.10 ± 0.28cdef	111.90 ± 0.57fgh	161.45 ± 4.88def
S3F4	16.45 ± 1.06	32.25 ± 2.90bcd	66.85 ± 1.63cdef	94.25 ± 2.76abcde	119.10 ± 0.99defgh	155.80 ± 0.85efg
S4F0	17.15 ± 0.78	34.70 ± 0.57abcd	69.15 ± 3.04cdef	93.70 ± 5.66abcde	118.25 ± 14.07defgh	150.50 ± 7.50fg
S4F1	15.85 ± 0.35	32.60 ± 1.13abcd	66.25 ± 2.62cdef	96.95 ± 5.87abcd	126.25 ± 12.52abcdefg	154.95 ± 1.77efg
S4F2	15.75 ± 0.35	32.25 ± 2.33bcd	66.75 ± 4.17cdef	98.95 ± 5.16abcd	128.45 ± 13.65abcdef	155.10 ± 11.60efg
S4F3	15.80 ± 0.28	31.70 ± 0.42bcd	68.10 ± 5.94cdef	97.85 ± 7.57abcd	123.00 ± 8.91bcdefgh	168.30 ± 7.21bcdef
S4F4	15.70 ± 0.57	33.85 ± 1.48abcd	73.60 ± 3.54abcde	107.60 ± 14.42a	139.40 ± 28.43ab	173.75 ± 27.08abcde
CV (%)	7.18	5.88	6.93	6.75	5.84	5.05

Note: Mean ± standard deviation, DAP: day after planting, ns: not significant, CV: coefficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

This was be fathomed because it was not directly related to the plant physiological aspects, but directly related to soil characteristics. Slopes were closely related to the quantity of soil organic carbon, total N, and enzyme activity by changing the rate of litter decomposition and soil microbial activity (Nahidan et al., 2015). The highest rate of plant height increase at the age of 28 DAP with an average percentage of plant height increase of 111.05% in all treatments and decreased until the age of 42 DAP. While, the highest rate of plant height increase with an average percentage of plant height increase of 70.56% was indicated by the slope 0% (flat) and NPK compound fertilizer as much as 50 kg ha^{-1}, while the rate of plant height increase was lowest with an average percentage of plant height increase of 58.12% only was shown by the slopes >35% (mountainous) and NPK compound fertilizer as much as 0 kg ha^{-1}.

Apparently, the effect of slopes began to be seen clearly in plant height from the age of 14 DAP to 42 DAP, where the flat slope had a significant effect on plant height and the peak effect of the slope was more pronounced at plant height aged of 35 and 42 DAP, followed by a undulating slope. The position of the slope has a significant effect on the maize growth (Changere and Lal, 1997). Hilly and mountainous slopes will receive more sunlight than undulating and flat slopes, so that decomposition of organic matter and nutrient cycling was better. Humidity is a basic environmental factor in a relatively dry area, so higher humidity at the shady slopes location can lead to better nutrition cycles and higher microbial community activity (Xue et al., 2018). The levels of C-organic, total N, P are available and K can be exchanged at the study site is relatively low (Table 1), so fertilizing action was needed. While the effect of NPK compound fertilizer began to be seen clearly in plant height later on from the age of 21 DAP to 42 DAP, where the fertilizing level of 100 kg ha^{-1} showed the highest plant height from the age of 28 DAP, 35 and 42 DAP, but it was not significantly different from the fertilizer level of 50 kg ha^{-1} and 200 kg ha^{-1} at the age of 21 DAP, 28, 35 and 42 DAP, except with fertilizer levels 0 kg ha^{-1} and 150 kg ha^{-1} were significantly different at the age of 28 DAP and 35 DAP. The NPK fertilization has a significant effect on the agronomic parameters of maize (Achiri et al., 2017). Nitrogen is another important soil nutrient that affects plant growth and water use efficiency (Sardans et al., 2008). The application of Phosphor fertilizer increases the efficient utilization of N fertilizer on the production of maize biomass (Mensah and Mensah, 2016). Potassium is needed for maize growth (Solihin et al., 2019).

The combination of slopes and NPK compound fertilizers began to showing a significant effect on plant height aged of 14 DAP to 42 DAP, while at age of 7 DAP had no significant effect (Table 2). The combination of flat slope (0-8%) to undulating slope (8-15%) with NPK fertilizer compound level of 100 kg ha^{-1} shows the highest plant height at the age of 21 DAP to 42 DAP. While on a combination of hilly slopes (15-35%) and mountainous slopes (35%) with all levels of fertilization was relatively varied. However, if the lands with these slopes will still be used for maize cultivation, then it will be sought only to land with hilly slopes (15-35%) combined with NPK compound fertilizer levels of 100 kg ha^{-1} because plant height reaches of 174.45 cm at age of 42 DAP. At low fertilization rates, the amount of N and K absorbed by plants increases with the amount of fertilizer applied (Niu et al., 2013). Maize plants absorb large amounts of N from the soil at V6 and maximum absorption occurs before silking (Ma' et al., 2003).

The effect of the slope on the leaves number shows the significant effect from the age of 7 DAP to 42 DAP, while the effect of compound NPK fertilization shows the significant effect later starting at age of 21 DAP to 42 DAP (Table 3). The highest rate of leaves number increasing occurred at the age of 14 DAP with an average percentage of leaves number increase of 79.70% in all treatments and decreased until the age of 42 DAP. The rate of increasing the leaves number with an average percentage leaves number increase by 38.16% was indicated by the slopes >35% (mountainous) and NPK compound fertilizer as much as 150 kg ha^{-1}, while the rate of increasing the leaves number with an average the percentage of leaves number increase was 29.94% only, as indicated by the slopes 15-35% (hilly) and NPK compound fertilizer as much as 200 kg ha^{-1}. Leaves number of maize increased significantly as the plants aged with NPK fertilizing (Titah et al., 2016). Effect of slope on the leaves number at age of 7 DAP shows the highest leaves number on hilly slopes (15-35%) and not significantly different from flat slopes (0-8%) and undulating slopes (8-15%), but significantly different from slopes mountainous (>35%). At the age of 14 DAP, the effect of hilly slopes still shows the highest leaves number and was significantly different from flat slopes and undulating slopes, while those with mountainous slopes are not significantly different. At the age of 21 DAP and 28 DAP, the effect of flat slope has shown the highest leaves number and was significantly different from all slope classes, except at the age of 28 DAP which was only significantly different from hilly slopes. While at the age of 35 DAP and 42 DAP, the effect of mountainous slopes shows the highest leaves number and was not significantly different from flat slopes.

The effect of NPK compound fertilizer on the leaves number at the age of 7 DAP shows the highest leaves number at the fertilizer level of 200 kg ha^{-1}, while at the age of 14 DAP the highest leaves number at the fertilizer level of 50 kg ha^{-1}, although at the two ages it was not significantly different from all fertilization levels. At the age of 21 DAP, NPK compound fertilization shown has significant effect with the highest leaves number at the fertilizer level of 50 kg ha^{-1} and significantly different from the fertilizer level of 0 kg ha^{-1} only. While at the age of 28 DAP to 42 DAP, the effect of compound NPK fertilizer on the most leaves number was indicated by the fertilizer level of 100 kg ha^{-1} and significantly different from the fertilizer level of 0 kg ha^{-1} only, except at age of 35 DAP apart from being significantly different from the level 0 kg ha^{-1} also with a fertilizer level of 50 kg ha^{-1}.

Table 3 – The average of number leaves of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Leaves Number (strands)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Slopes (S):						
S1 (0 – 8%)	3.26 ± 0.12b	5.33 ± 0.09a	8.32 ± 0.38a	9.68 ± 0.52b	10.99 ± 0.23c	12.24 ± 0.38bc
S2 (8 – 15%)	3.22 ± 0.08b	5.78 ± 0.20b	8.00 ± 0.15b	9.40 ± 0.38b	10.49 ± 0.48b	11.70 ± 0.46a
S3 (15 – 35%)	3.34 ± 0.15b	6.02 ± 0.22c	7.91 ± 0.18b	9.07 ± 0.29a	10.22 ± 0.28a	12.02 ± 0.40b
S4 (>35%)	2.99 ± 0.11a	5.83 ± 0.06bc	7.90 ± 0.29b	9.50 ± 0.34b	11.01 ± 0.33c	12.51 ± 0.53c
NPK Compound (F):						
F0 (0 kg ha^{-1})	3.22 ± 0.06ns	5.70 ± 0.32ns	7.73 ± 0.21a	8.88 ± 0.25a	10.22 ± 0.41a	11.43 ± 0.25a
F1 (50 kg ha^{-1})	3.15 ± 0.15	5.87 ± 0.31	8.18 ± 0.55b	9.48 ± 0.54b	10.55 ± 0.54b	12.21 ± 0.51b
F2 (100 kg ha^{-1})	3.23 ± 0.23	5.70 ± 0.20	8.07 ± 0.22b	9.63 ± 0.43b	10.93 ± 0.27c	12.38 ± 0.19b
F3 (150 kg ha^{-1})	3.13 ± 0.21	5.65 ± 0.29	8.06 ± 0.02b	9.51 ± 0.23b	10.87 ± 0.48c	12.33 ± 0.24b
F4 (200 kg ha^{-1})	3.26 ± 0.22	5.77 ± 0.44	8.10 ± 0.15b	9.53 ± 0.28b	10.80 ± 0.42bc	12.21 ± 0.66b
Combinations (SF):						
S1F0	3.30 ± 0.00abc	5.25 ± 0.07e	8.00 ± 0.28cde	9.10 ± 0.42cdef	10.60 ± 0.42abc	11.65 ± 0.64cde
S1F1	3.20 ± 0.14abc	5.45 ± 0.21cde	8.95 ± 0.49a	10.25 ± 1.06a	11.15 ± 0.49ab	12.65 ± 0.49ab
S1F2	3.45 ± 0.21ab	5.40 ± 0.14cde	8.40 ± 0.28b	10.20 ± 0.14ab	11.15 ± 0.64ab	12.40 ± 0.57abc
S1F3	3.20 ± 0.42abc	5.25 ± 0.21e	8.10 ± 0.42cde	9.50 ± 0.28abcde	11.00 ± 0.14ab	12.40 ± 0.57abc
S1F4	3.15 ± 0.21abc	5.30± 0.28de	8.15 ± 0.35bcd	9.35 ± 0.64cdef	11.05 ± 0.49ab	12.10 ± 0.28bcd
S2F0	3.20 ± 0.28abc	5.70 ± 0.14bcde	7.80 ± 0.00efg	8.75 ± 0.21ef	9.95 ± 0.07e	11.15 ± 0.07e
S2F1	3.30 ± 0.14abc	6.10 ± 0.42ab	8.15 ± 0.21bcd	9.45 ± 0.07bcde	10.05 ± 0.07de	11.50 ± 0.14de
S2F2	3.15 ± 0.07abc	5.85 ± 0.21abcd	7.90 ± 0.00def	9.70 ± 0.85abcd	11.05 ± 0.78ab	12.25 ± 1.06bcd
S2F3	3.15 ± 0.21abc	5.65 ± 0.07bcde	8.05 ± 0.07cde	9.50 ± 0.28abcde	10.85 ± 0.07abc	12.10 ± 0.14bcd
S2F4	3.30 ± 0.14abc	5.60 ± 0.14bcde	8.10 ± 0.00cde	9.60 ± 0.57abcd	10.55 ± 0.21bcd	11.50 ± 0.42de
S3F0	3.25 ± 0.49abc	5.95 ± 0.49abc	7.60 ± 0.14g	8.60 ± 0.14f	9.80 ± 0.28e	11.30 ± 0.28e
S3F1	3.15 ± 0.07abc	6.10 ± 0.28ab	8.00 ± 0.28cde	9.00 ± 0.00def	10.15 ± 0.07de	12.20 ± 0.14bcd
S3F2	3.40 ± 0.14ab	5.75 ± 0.35bcde	8.00 ± 0.14cde	9.20 ± 0.00cdef	10.55 ± 0.07bcd	12.25 ± 0.35bcd
S3F3	3.35 ± 0.07abc	5.95 ± 0.21abc	8.05 ± 0.07cde	9.25 ± 0.07cdef	10.25 ± 0.07de	12.20 ± 0.14bcd
S3F4	3.55 ± 0.07a	6.35 ± 0.07a	7.90 ± 0.14def	9.30 ± 0.00cdef	10.35 ± 0.21cde	12.15 ± 0.07bcd
S4F0	3.15 ± 0.07abc	5.90 ± 0.14abc	7.55 ± 0.07g	9.10 ± 0.00cdef	10.55 ± 0.21bcd	11.65 ± 0.49cde
S4F1	2.95 ± 0.07bc	5.85 ± 0.21abcd	7.65 ± 0.07fg	9.25 ± 0.07cdef	10.85 ± 0.07abc	12.50 ± 0.28ab
S4F2	2.95 ± 0.07bc	5.80 ± 0.28abcde	8.00 ± 0.14cde	9.45 ± 0.07bcde	11.00 ± 0.14ab	12.65 ± 0.07ab
S4F3	2.85 ± 0.07c	5.75 ± 0.07bcde	8.05 ± 0.21cde	9.80 ± 0.14abcd	11.40 ± 0.14a	12.65 ± 0.64ab
S4F4	3.05 ± 0.21abc	5.85 ± 0.07abcd	8.25 ± 0.07bc	9.90 ± 0.14abc	11.25 ± 0.21a	13.10 ± 0.28a
CV (%)	6.39	4.01	1.54	3.48	2.32	2.71

Note: Mean ± standard deviation, DAP: day after planting, CV: coefficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The combination of slope and compound NPK fertilizer shows a significant effect on the leaves number starting at age of 7 DAP to 42 DAP (Table 3). The combination of hilly slopes with NPK compound fertilizer of 200 kg ha^{-1} level shows the highest leaves number at the age of 7 DAP to 14 DAP and was significantly different with the combination of mountainous slopes with fertilizer levels of 50, 100 and 150 kg ha^{-1} at age of 7 DAP only, as well as a combination of flat slope and fertilizer level of 0 kg ha^{-1} to 200 kg ha^{-1}, a combination of undulating slopes with fertilizer levels of 0 kg ha^{-1}, 150 and 200 kg ha^{-1}, a combination of hilly and mountainous slopes with levels 100 kg ha^{-1}. While at the age of 21 DAP, the highest leaves number was indicated by a combination of flat slope and 50 kg ha^{-1} fertilizer level that was significantly different from all treatment combinations. The same pattern was also shown by the highest leaves number at the age of 28 DAP on a combination of flat slope and 50 kg ha^{-1} fertilizer level, but significantly different from the twelve other treatment combinations. At the age of 35 DAP, the effect of mountainous slopes with fertilizer level of 150 kga ha^{-1} combination showed the highest leaves number and was significantly different from nine other treatment combinations, whereas at age of 42 DAP the highest leaves number was indicated by a combination of mountainous slopes with a fertilizer level of 200 kg ha^{-1} and significantly different from thirteen other treatment combinations.

Effect of slopes and NPK compound fertilizer on maize yields. The effects of slopes and compound NKP fertilizers show a significant effect on all yield components (Table 4). On the flat slope (0-8%), the male flowers (42.21 DAP) and the female maize flowers (47.64 DAP) were the most significantly different from the other slopes, while on the hilly slopes (15-35%) the male flowers were the longest (45.84 DAP) and female flowers (49.31 DAP). The highest of cob weight and grain yields on the flat slope (0-8%) that it was significantly different from other slopes, except that the cob weight was not significantly different from other slopes. The highest of cob weight percentage ton grain yield was shown by mountainous slopes (>35%) and has not significantly different from flat slopes. The slope position also has a significant effect on maize yield (Changere and Lal, 1997), as the slope and organic fertilizer have a significant and very significant effect on potato yield (Wati et al., 2014). The 10-22% lower content of organic matter, nitrogen, and phosphorus on the lower middle slope is associated with a decrease in maize yield of 27% compared to the position of the upper middle slope (Wezel et al., 2002).

The effect of NPK compound fertilizer on the age of male and female maize flowers was the fastest out (44.87 DAP and 48.22 DAP respectively) and the highest cob weight was shown by the fertilizer level of 100 kg ha^{-1} which was significantly different with the level of fertilizer 0 kg ha^{-1} only. While the highest of grain yields hass shown by the fertilizer level of 200 kg ha^{-1} but not significantly different from the fertilizer level of 100 kg ha^{-1}, whereas the highest of cob weight percentage to grain yield was indicated by the level of 50 kg ha^{-1} and significantly different with the level of 0 kg ha^{-1} and 200 kg ha^{-1} only. The NPK fertilization has a significant effect on maize yield parameters (Achiri et al., 2017). Flowering time can often be accelerated 3-10 days by application of NPK fertilizer (Gumeleng, 2003). Female maize flowering were most quickly obtained at the fertilizer level of 250 kg ha^{-1} N, 100 kg ha^{-1} P and 75 kg ha^{-1} K whereas the latest were obtained at 0 kg ha^{-1} level (Nurdin et al., 2009). Phosphor is able to increase the photosynthesis process which will further influence the increase in dry weight of plants (Minardi, 2002).

Table 4 – The average of component yield of maize local of Motoro Kiki varieties due to slopes and NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Male Flowering Age (DAP)	Female Flowering Age (DAP)	Cob Weight (t ha^{-1})	Grain Yields (t ha^{-1})	Percentage of Cob Weight to Grain Yields (%)
Slopes (S):					
S1 (0 – 8%)	44.21 ± 0.84a	47.64 ± 0.70a	1.78 ± 0.27ns	3.06 ± 0.25c	20.43 ± 2.39a
S2 (8 – 15%)	45.53 ± 0.49b	48.92 ± 0.70b	1.51 ± 0.37	2.48 ± 0.37ab	22.49 ± 2.93ab
S3 (15 – 35%)	45.84 ± 0.54b	49.31 ± 0.74b	1.70 ± 0.31	2.56 ± 0.47b	24.27 ± 3.37b
S4 (>35%)	45.53 ± 0.77b	48.82 ± 0.86b	1.55 ± 0.29	2.18 ± 0.33a	25.31 ± 4.14b
NPK Compound (F):					
F0 (0 kg ha^{-1})	45.92 ± 1.17b	49.57 ± 1.24a	1.19 ± 0.24a	2.15 ± 0.46a	20.36 ± 2.20a
F1 (50 kg ha^{-1})	45.01 ± 1.01ab	48.42 ± 0.85b	1.65 ± 0.31b	2.41 ± 0.49a	26.37 ± 3.77b
F2 (100 kg ha^{-1})	44.87 ± 1.14a	48.22 ± 1.15b	1.81 ± 0.26b	2.87 ± 0.50bc	23.03 ± 5.23ab
F3 (150 kg ha^{-1})	45.25 ± 0.57ab	48.59 ± 0.58b	1.74 ± 0.18b	2.49 ± 0.21ab	24.19 ± 1.49ab
F4 (200 kg ha^{-1})	45.34 ± 0.43ab	48.57 ± 0.49b	1.78 ± 0.12b	2.93 ± 0.34c	21.66 ± 1.62a
Combinations (SF):					
S1F0	44.25 ± 1.63bcd	47.75 ± 1.81bcd	1.48 ± 0.42abcde	2.80 ± 0.67abcd	19.71 ± 0.85cde
S1F1	43.50 ± 0.28cd	47.17 ± 0.28cd	2.08 ± 0.21ab	3.23 ± 0.42ab	21.21 ± 3.68abcde
S1F2	43.35 ± 0.12d	46.80 ± 0.05d	1.49 ± 0.68abcde	3.20 ± 0.18ab	16.94 ± 7.83e
S1F3	44.52 ± 1.06bcd	47.86 ± 0.94bcd	1.87 ± 0.32abc	2.78 ± 0.06abcd	23.50 ± 3.25abcde
S1F4	45.42 ± 0.49abcd	48.61 ± 0.54abcd	1.95 ± 0.03abc	3.30 ± 0.11a	20.77 ± 1.29abcde
S2F0	45.98 ± 1.15ab	49.85 ± 1.01ab	0.92 ± 0.13e	2.04 ± 0.42de	18.08 ± 5.14de
S2F1	45.67 ± 0.71ab	48.91 ± 0.68abc	1.35 ± 0.25bcde	2.18 ± 0.67cde	25.93 ± 1.17abcde
S2F2	44.71 ± 0.68abcd	47.90 ± 0.61bcd	1.77 ± 0.05abcd	2.91 ± 0.47abcd	23.06 ± 5.15abcde
S2F3	45.48 ± 0.45abc	48.83 ± 0.33abcd	1.76 ± 0.44abcd	2.48 ± 1.03abcde	23.83 ± 5.83abcde
S2F4	45.80 ± 0.90ab	49.08 ± 0.82abc	1.73 ± 0.47abcd	2.79 ± 0.45abcd	21.58 ± 0.97abcde
S3F0	46.65 ± 0.26a	50.46 ± 0.38a	1.28 ± 0.10cde	1.99 ± 0.24de	23.33 ± 1.86abcde
S3F1	45.30 ± 1.79abcd	48.65 ± 1.72abcd	1.59 ± 0.14abcde	2.19 ± 0.44cde	28.87 ± 3.52abc
S3F2	46.00 ± 0.57ab	49.51 ± 0.73ab	2.13 ± 0.02a	3.22 ± 0.39ab	22.42 ± 2.67abcde
S3F3	45.86 ± 0.94ab	49.23 ± 0.94abc	1.83 ± 0.01abcd	2.30 ± 0.34bcde	26.38 ± 3.49abcd
S3F4	45.38 ± 0.07abcd	48.70 ± 0.00abcd	1.67 ± 0.17abcd	3.09 ± 0.46abc	20.32 ± 0.93bcde
S4F0	46.80 ± 0.42a	50.20 ± 0.33a	1.09 ± 0.38de	1.76 ± 0.46e	20.30 ± 0.78bcde
S4F1	45.55 ± 0.49abc	48.95 ± 0.26abc	1.57 ± 0.27abcde	2.05 ± 0.36de	29.48 ± 0.81ab
S4F2	45.43 ± 0.52abc	48.65 ± 0.45abcd	1.83± 0.09abcd	2.16 ± 0.10cde	29.71 ± 3.46a
S4F3	45.11 ± 0.68abcd	48.41 ± 0.59abcd	1.48 ± 0.12abcde	2.38 ± 0.23abcde	23.08 ± 1.32abcde
S4F4	44.75 ± 1.58abcd	47.90 ± 1.84bcd	1.77 ± 0.07abcd	2.53 ± 0.39abcde	23.96 ± 3.55abcde
CV (%)	1.88	1.77	18.54	18.53	16.34

Note: Mean ± standard deviation, DAP: day after planting, CV: coefficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The combination of slope and NPK compound fertilizer shows a significant effect on all yield components (Table 4). The combination of flat slope with NPK compound fertilizer level of 100 kg ha^{-1} shows the age of male and female maize flowering fastest and has significantly different from the ten slope combinations and fertilizer level at age of male maize flowering, and significantly different from the eight slope combinations and other fertilizer levels at age of female maize flowering. Meanwhile, the highest of cob weight was shown by a combination of hilly slopes and fertilizer level of 100 kg ha^{-1} which was significantly different from four other treatment combinations only. The highest of grain yiled was shown by the combination of flat slope and fertilizer level of 200 kg ha^{-1}, but it was significantly different from only eight other treatment combinations. Whereas the highest of cob weight percentage to grain yiled was shown by the combination of mountainous slopes with a fertilizer level of 100 kga ha^{-1} and significantly different from five other treatment combinations only. The best combination of slope and NPK compound fertilizer on maize yield parameters was flat slope with fertilizer level of 100 kg ha^{-1}. This was in line with the report of Ngosong et al., (2019) that N fertilizing between 50 and 100 kg N ha^{-1} was optimal for maize production in Cameroon's volcanic soil.

Relative agronomic and economic fertilization effectiveness. The highest of relative agronomic effectiveness (RAE) values, the ratio of economic fertilization effectiveness (EFE) with subsidized fertilizer and non-subsidized was shown by flat slopes (0-8%) which differ significantly by undulating slopes (8-15%) and mountainous slopes (>35%) on RAE, significantly different from all slopes in the EFE subsidized and non-subsidized ratio (Table 5), in other to the distribution was obtained following the RAE pattern S1> S3> S2> S4. Provision of standard or recommended of NPK Fertilizers (300 kg ha^{-1} NPK+250 kg ha^{-1} Urea) shows a higher RAE value (100) than other fertilizer doses to maize plants (Kasno, 2010; Wijaya et al., 2015; Erselia et al., 2017; Subandi et al., 2017), in sugarcane (Zulkarnain et al., 2017). Furthermore, the highest of the RAE value, EFE subsidized and non-subsidized ratio with NPK compound fertilization was shown by fertilizer level of 200 kg ha^{-1} which was not significantly different with fertilizer level of 50 kg ha^{-1} and 100 kg ha^{-1} at RAE, and has not significantly different only with the level of 100 kg ha^{-1} in the EFE subsidized and non-subsidized ratio, so as the distribution was obtained following the pattern F4> F2> F3> F1> F0.

Table 5 – Relative agronomic effectiveness (RAE) and economic fertilizer effectiveness (EFE) of maize yields with NPK compound fertilizer to Inceptisol Bumela, Indonesia

Treatments	Grain Yields (t ha^{-1})	RAE (%)	Ratio of EFE (Subsidized Fertilizer)	Ratio of EFE (Non-Subsidized Fertilizer)
Slopes (S):				
S1 (0 – 8%)	3.06 ± 0.25c	131.98 ± 127.63a	4.66 ± 0.38a	1.34 ± 0.11a
S2 (8 – 15%)	2.48 ± 0.37ab	45.77 ± 38.99b	3.77 ± 0.57bc	1.08 ± 0.16bc
S3 (15 – 35%)	2.56 ± 0.47b	56.24 ± 55.19ab	3.89 ± 0.85b	1.12 ± 0.24b
S4 (>35%)	2.18 ± 0.33a	33.55 ± 24.19b	3.31 ± 0.46c	0.95 ± 0.13c
NPK Compound (F):				
F0 (0 kg ha^{-1})	2.15 ± 0.46a	0.00 ± 0.00c	3.26 ± 0.69c	0.94 ± 0.20c
F1 (50 kg ha^{-1})	2.41 ± 0.49a	68.50 ± 98.78abc	3.66 ± 0.84c	1.05 ± 0.24c
F2 (100 kg ha^{-1})	2.87 ± 0.50bc	111.47 ± 70.62ab	4.36 ± 0.75ab	1.26 ± 0.22ab
F3 (150 kg ha^{-1})	2.49 ± 0.21ab	28.69 ± 28.59bc	3.79 ± 0.32bc	1.09 ± 0.09bc
F4 (200 kg ha^{-1})	2.93 ± 0.34c	125.77 ± 87.65a	4.45 ± 0.51a	1.28 ± 0.15a
Combinations (SF):				
S1F0	2.80 ± 0.67abcd	0.00 ± 338.69c	4.26 ± 1.01abcd	1.23 ± 0.29abcd
S1F1	3.23 ± 0.42ab	216.57 ± 215.72ab	4.91 ± 0.65ab	1.41 ± 0.19a
S1F2	3.20 ± 0.18ab	201.63 ± 93.48abc	4.87 ± 0.28ab	1.40 ± 0.08ab
S1F3	2.78 ± 0.06abcd	-12.33 ± 31.98c	4.23 ± 0.10abcd	1.22 ± 0.03abcd
S1F4	3.30 ± 0.11a	254.05 ± 58.19a	5.02 ± 0.17a	1.44 ± 0.05a
S2F0	2.04 ± 0.42de	0.00 ± 44.09c	3.10 ± 0.64de	0.89 ± 0.18de
S2F1	2.18 ± 0.67cde	14.41 ± 69.87bc	3.31 ± 1.02cde	0.95 ± 0.29cde
S2F2	2.91 ± 0.47abcd	90.14 ± 49.05abc	4.42 ± 0.72abcd	1.27 ± 0.21abcd
S2F3	2.48 ± 1.03abcde	46.41 ± 107.49abc	3.78 ± 1.57abcde	1.09 ± 0.45abcde
S2F4	2.79 ± 0.45abcd	77.91 ± 46.97abc	4.24 ± 0.68abcd	1.22 ± 0.20abcd
S3F0	1.99 ± 0.24de	0.00 ± 23.75c	3.03 ± 0.36de	0.87 ± 0.10de
S3F1	2.19 ± 0.44cde	19.93 ± 44.03bc	3.33 ± 0.68cde	0.96 ± 0.19cde
S3F2	3.22 ± 0.39ab	121.84 ± 38.66abc	4.90 ± 0.59ab	1.41 ± 0.17ab
S3F3	2.30 ± 0.34bcde	30.75 ± 33.48bc	3.50 ± 0.51bcde	1.01 ± 0.15bcde
S3F4	3.09 ± 0.46abc	108.67 ± 45.97abc	4.69 ± 0.71abc	1.35 ± 0.20abc
S4F0	1.76 ± 0.46e	0.00 ± 37.02c	2.67 ± 0.70e	0.77 ± 0.20e
S4F1	2.05 ± 0.36de	23.07 ± 29.31bc	3.11 ± 0.55de	0.89 ± 0.16de
S4F2	2.16 ± 0.10cde	32.28 ± 8.21bc	3.28 ± 0.15cde	0.94 ± 0.04cde
S4F3	2.38 ± 0.23abcde	49.93 ± 18.84abc	3.62 ± 0.36abcde	1.04 ± 0.10abcde
S4F4	2.53 ± 0.39abcde	62.46 ± 31.35abc	3.85 ± 0.59abcde	1.11 ± 0.17abcde
CV (%)	18.53	160.21	18.52	18.57

Note: Mean ± standard deviation, CV: coeficient of variant, Values sharing same letters differ non-significantly at Duncan Multiple Range Test (P > 0.05).

The highest of RAE, the EFE subsidized and non-subsidized ratio in the combination of slope and NPK compound fertilization has shown by the combination of flat slope with fertilizer level 200 kg ha^{-1} which was significantly different from the ten other treatment combinations at RAE value and significantly different from eight other treatment combinations at the EFE subsidized and non-subsidized ratio (Table 5). While the lowest RAE value was indicated by the combination of flat slope with fertilizer level of 150 kg ha^{-1} which was significantly different from the combination of flat slope and fertilizer level of 50 kg ha^{-1} only, the EFE subsidized and non-subsidized ratio was indicated by the combination of mountainous slopes with fertilizer level of 0 kg ha^{-1} and significantly different from ten other treatment combinations. Thus, the combination of a flat slope with a fertilizer level of 100 kg ha^{-1} is the best combination that can be applied by maize farmers. This was in line with the report of Wijaya et al. (2015) that fertilizing urea at 100 kg ha^{-1}, SP-36 at 200 kg ha^{-1} and KCl at 100 kg ha^{-1} showed the highest EFE ratio in both subsidized and non-subsidized fertilizers. However, if farmers will continue to maize cultivating on sloping land, it was recommended to arrive at hilly slopes (15-35%) with fertilizer levels of 100 kg ha^{-1} only.

CONCLUSION

The slope and NPK compound fertilization can increase the maize growths. The best combination in increasing plant height and leaves number was the combination of flat slope and fertilizer level of 100 kg ha^{-1}. The slope and NPK compound fertilization can increase the maize yields. The best combination in accelerating the age of male and female maize flowering, increasing the grain yield was the combination of flat slope and fertilizer level of 100 kg ha^{-1}. While on cob weight was combination of hilly slope and fertilizer level of 100 kg ha^{-1}, whereas on the percentage of cob weight to grain yield was a combination of mountainous slope and fertilizer level of 100 kg ha^{-1}. The slope and NPK compound fertilization can increase the RAE percentage, the EFE subsidized and non-subsidized ratio. The best combination of flat slopes and compound NPK fertilization level of 200 kg ha^{-1} has significantly increase the percentage of RAE, the EFE subsidized and non-subsidized ratio, but relatively equal to the the level of 100 kg ha^{-1}. If farmers will continue to maize cultivating on the sloping land, it was recommended to arrive at hilly land with a fertilizer level of 100 kg ha^{-1} only.

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