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DETERMINATION OF THE EFFICIENCY AND EFFICACY OF BIO-CHEMICAL FERTILIZER ON THE SOIL, YIELD AND GROWTH PERFORMANCE OF BLACK PEPPER (Piper nigrum L.)

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ABSTRACT

The last nutrient management review of black pepper was done in 1968. There is, therefore, a need to develop new technology to improve pepper production and transfer that technology to production site. This experiment was carried out to study the effect of newly developed biochemical fertilizer on some physiological characteristics, yield and soil fertility of pepper. The treatment consisted of T1 (BS): chemical fertilizer (N:12%, P:12%, K:17%); T2 (BK1): biochemical fertilizer F1 N:15%, P:5%, K:14) and T3 (BK2): biochemical fertilizer F2 (N:13%, P:4%, K:12). The biochemical fertilizer F1 out-yielded chemical and biochemical fertilizer F2 by 75.38% and 16.45% respectively with the higher yield being associated with various phonotypical alterations, which are reported here. Significant measureable changes were observed in physiological processes and plant characteristics, such as large leaf area index, more chlorophyll content and high photosynthesis rate coupled with lower transpiration rate in biochemical fertilizer F1(BK1) treatment compared with other treatment. The high fertility level in biochemical fertilizer F1 and biochemical fertilizer F2 (BK2) reflected the important of organic material in improving soil quality. In conclusion, the achieve high growth performance and yield in pepper, chemical fertilizer alone is insufficient whilst combination of organic and inorganic fertilizer with balance nutrient content gave a significant increase in yield and growth of pepper.

Keywords

Piper nigrum L.; biochemical fertilizer; leaf area index; photosynthesis; transpiration; yield.

Abbreviations

N: Nitrogen, P: Phosphorus, K: Potassium

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1.0 INTRODUCTION

The black pepper of commerce is produced from the most important species of the genus *Piper* of the family Piperaceae. Pepper has been known from ancient times and has been referred to as the "King of Spices" and "Black Gold" revealing the important attached to the spice. High yield production of pepper is urgently needed to meet the increasing population and growing demand for food. Malaysia is one of the largest producer and exporter in the world and is currently ranked sixth among the largest producers of black pepper at global level [1]. Pepper now ranked as the third most important agriculture export earner after palm oil and rubber. Since this industry is mainly focused on smallholder farmers, thus this industry provides employment to more than 70,000 smallholder farmers whose average farm size is 0.2 hectares.

Most recent available statistics placed its total area at 14,735 hectare and its total pepper production at 25,672 metric tons (t) with the production of giving yield of 4.6 ton per hectare. This yield is relatively low compared to other developing countries like Vietnam (50,000 ha), India (231,000 ha) and Indonesia (171,000 ha) [2]. There are many reasons for this low production of pepper in Malaysia.Poor nutrient management constituting the most important limiting factors.

One of the main problems faced by the pepper farmers is the high cost of production due to the increasing trends of using inorganic fertilizers. The problem becomes complex, as black pepper is a high nutrient demanding crop [3]. High amount of inorganic fertilizers are applied to pepper in order to achieve a higher yield and maximum value of growth. However, the use of inorganic fertilizers alone may cause problems for human health and the environment [4]. Therefore, it is important to develop cost effective methods to fulfil the nutrient demand of black pepper and at the same time alleviate the environmental hazards. As organic farming is becoming popular among pepper farmers, one of the options to reduce the use of chemical fertilizers could be utilization of organic fertilizers.

In the early sixties, the quantitative data on nutrients involved in growth and reproductive process of the pepper vines is vey limited. The first fertilizer trialon black pepper was began in 1959 with the appointment of the first pepper agronomist. This trial was conducted to assess the response of compound fertilizer with Nitrogen(N), Phosphorus (P) and Potassium (K) ratio of 12:12:17 on plant growth and yield. A review of manurial trials was made in 1968 and a general recommendation for fertilizer application subsequently published [5]. This recommedation was adopted by the Department of Agriculture sarawak,and it has been in use up to now. From that time onward, no major transformation has been done on the fertilizer application practices. There is, therefore, a need to develop technology to improve pepper production and transfer that technology to production site. The objective of this study was to determine the effect of newly developed bio-chemical fertilizers the on the vegetative growth, yield and quality of black pepper.This study also forms part of an ongoing effort to collect growth analysis data for establishing science based nutrient management of pepper vines.

2.0 MATERIALS AND METHODS

The experiment was carried out during the period of 2013 to 2014 at a farmer's land in Julau Sarawak, on Tarat soil series. The particle size analysis showed that the texture of this brownish red soil was clay loam and had a pH of 3.67 (Table 1). Geographical location of the experimental site was 112° 54' 47" E latitude and 1° 46' 26" N Longitude with average altitude of 40.21 m above sea level with the average temperature ranging between 30°C - 35°C during the day, and 27°C - 29°C at night with the average annual rainfall being about 3500 mm.

Table 1: Initial chemical characteristics of Julau, Sarawak soil

Chemical properties	Soil depth (0-25cm)
pH	3.67
CEC (cmol(+)/ kg)	10.1
Exchangeable K^+ (cmol(+)/ kg)	0.16
Exchangeable Mg^{2+} (cmol(+)/ kg)	0.12
Exchangeable Ca^{2+} (cmol(+)/ kg)	1.45
Exchangeable Na^+ (cmol(+)/ kg)	0.05
Organic carbon (%)	1.98
C/N ratio	8.25
Total nitrogen (%)	0.24
Available phosphorus (mg/kg)	9.85
Total potassium (mg/kg)	29.75

A completely randomised block design (RCBD) was used. Pepper vines of the variety *Kuching* were planted in rows with spacing of 2.1 m x 2.1 m between and within the rows, with a population of 2,000 plants per hectare. The site was divided into three blocks or replicates. Each block contained four treatments and 100 plants of *Piper nigrum* were planted for each treatment.

The three treatments consisted of (BS): chemical fertilizer (recommended fertilizer appplication). Within this treatment, the pepper vines were randomly selected to receive the NPK fertilizer (12%: 12%: 17%: 2% (Mg) + trace elements) at the rate of one, two and three tons of compound fertiliser per hectare per year for the first, second and third year of planting, respectively. This rate of fertilizer corresponded to 120 kg ha^{-1} of N and P, 170 kg ha^{-1} of K and 20 kg ha^{-1} of Mg in the first year, 240 kg ha^{-1} of N and P, 340 kg ha^{-1} of K and 40 kg ha^{-1} of Mg in the second year and 360 kg ha^{-1} of N and P, 510 kg ha^{-1} of K and 60 kg ha^{-1} of Mg in the third year of planting. NPK compound fertiliser was applied 6 times annually (every 2-month intervals), following Malaysian Pepper Board's recommendation rate based on their expected productivity [6]. In addition, ground magnesium limestone was applied to neutralise the soil acidity.

The second treatment was BK1 which involved the application of Biochemical fertilizer, formula 1 (BK 1). This fertilizer consisted of 20% organic matters, chemical fertilizer (15%: 5%: 14%: 2% (Mg) + trace elements) and effective microorganisms. The chemical compositions of biochemical fertilizer are described in Table 2. Under this treatment, the application rates of fertilizer are the same as applied in treatment 1. All the fertilizers were broadcasted evenly surrounding the mound, about 30-50 cm from the main stem. For the third treatment (T3),Biochemical fertilizer with different NPK formula (13:4:12) was utilized. The application rates and application method are the same as applied in treatment 1.

Upon completion of the experiment, the plants were harvested at maturity for yield and yield component. To assess leaf area, ten (10) pepper vines from each replicate were randomly selected and leaf areas were measured using a leaf area meter (CI-202 Laser Area Meter). Leaf area index was determined by using LAI meter (LICOR-2200TC Canopy Analyser). The pepper plant was then oven dried at 70^0C for 72 h and dry weight was also recorded. Concentration of photosynthesis pigment (chlorophyll) as well as photosynthesis rate and transpiration were measured in mature leaf samples taken 30 months after planting by using portable photosynthesis system (PPS System, model TPS 200). After the plant samples were taken, the soil samples were collected and analysed. Standard methods were adopted for pH [7], cation exchange capacity [8], organic carbon [7] and the concentration of nitrogen [9], phosphorus [10] and potassium [11]. For leaf nutrients content, mature leaves were collected and oven-dried before P, K, Mg and Ca contents were analysed by using dry ashing method as described by [12] and the Kjeldahl method [13] was used to determine total N. All data obtained were subjected to Analysis of Variance (ANOVA) and Duncan Multiple Ranged Test using Statistical Package for Social Science (SPSS) software.

Table 2 : Chemical properties of Bio-chemical fertilizer

Chemical properties of Biochemical fertilizers formula 1 (BK 1)

NPK ratio	:	N (15), P (5), K(14), Mg(2) + TE (80% of the fertilizer contain)
Organic matter	:	20% of fertilizer content (consist of cocoa and coffee waste, empty fruit braches and rice husk)
Effective microorganisms	:	(i) Beneficial microorganism for controlling soil pathogens (ii) Beneficial microorganism for enhancing the growth and production of black pepper

Chemical properties of Biochemical fertilizerformula 2 (BK 2)

NPK ratio	:	N (13), P (4), K(12), Mg(2) + TE (80% of the fertilizer contain)
Organic matter	:	20% of fertilizer content (consist of cocoa and coffee waste, empty fruit branches and rice husk)
Effective microorganisms	:	(iii) Beneficial microorganism for controlling soil pathogens (iv) Beneficial microorganism for enhancing the growth and production of black pepper

3.0 RESULTS AND DISCUSSION

3.1 Berries size

The pepper berries size per plot over the years were significantly different among the treatment when different fertilizer treatment were applied (Table 3).

Table 3: Effect of different fertilizer treatment on pepper berries. BK1: Bio-chemical fertilizer (15:5:14) fertilizer treatment, BK 2: Bio-chemical fertilizer (13:4:12) fertilizer treatment, and BS: chemical fertilizer treatment

Treatment	BK 1 (15:5:14)	BK 2 (13:4:12)	BS (12:12:17)
Parameter			
Weight of berries size > 4mm (g)	368.20	356.00	333.00
Weight of berries size < 4mm (g)	31.80	44.00	67.00
Total (g)	**400.00**	**400.00**	**400.00**
% Weight of berries size > 4mm	92.05a	89.00ab	83.25b
% Weight of berries size <4mm	7.95c	11.00b	16.75a

The berries size of the pepper berries grown under BK 1 treatments (92.05%) was higher than those grown under BK2 (89.00%), and BS treatment (83.25%). This indicated that the application of Biochemical fertilizer with the NPK ratio (15: 5: 14)enable to increase the production of pepperby assuming the pepper vine producing same number of spike and berries. A significant increase in percentage of pepper berries in BK 1 and BK2 treatment as compared to BS might probably due to the application of extra organic matter that are available in BK 1 and BK 2 fertilizer. This observation is supported by Aloola, 2006 [14] who reported that enhancement of crop yield through the integrated fertilizer regime (organic and chemical fertilizer). Besides, the increase of pepper berries in BK1 fertilizer treatment might also be due to the available of beneficial microbes in the fertilizer itself that can cause the enlargement of pepper berries.

3.2 Pepper berries quality

The quality of pepper is depended on physio-chemical properties of berries such as moisture content, volatile oil, piperine and non- volatie ethyl extract(NVEE). Based on the results obtained, the chemical properties of pepper berrries under BK1 and BK2 fertilizer treatment were higher than berries grown under chemical fertilizer treatment (Table 2).

The moisture content of pepper berries under BK 1, BK2 and BS fertilizer treament are dried enough for comsuption and export purposes with BK 1 fertilizer treatment value of 12.19%, BK 2, 13.00% and BS fertilizer treatment value of 13.49%. Based on MPB standard, the pepper berries fall within 12-15% can be considered as good white pepper (Range from No 1 creamy white to FAQ grade).

The volatile oil, piperine and non-volatile ethyl extract (NVEE)content in Biochemical fertilizer treatment is much higher than chemical fertilizer treatment with the volation oilcontent of 5.48%, piperine 8.47% and NVEE 8.74% in BK 1, 5.45% volation oil content , 8.63% piperine and 8.86%NVEE in BK 2 respectively. The chemical fertilizer treatment given the lowest pepper quality as compared tobiochemical fertilizer with the volation oil content of 4.83%, piperine 7.63% and NVEE 8.33%. The reduction in physio-chemical properties of pepper berries treated with chemical fertilizer treatment might probably due to the chemical reaction of chemical fertilizer with certain chemical compounds in the pepper berries. Previous finding also support this finding as application of organic fertilizer is able to increase the quality of wheat flour, because of increasing the amount of gluten after compost treatment [15].

In term of light berriescontent, berries treated with BK 1and BK 2 fertilizer regime are able to reduce the light berries contentfor 70.1% and 62.4% as compared to chemical fertilizer regime respectively. This could be due to limited nutrient that the soil could supply with the additional of a small quantitiy of external input. This finding is further comfirmed by the research reported by Yap [3]. He stated that pepper crop required approximately 293-46-265 kg of N-P-K per hectare annually in order to sustain high yield and soil nutrient balance.

Bulk Density is the most important criteria to determine the quality and price of the black pepper. Under MPB scale, pepper with bulk density between 580g/L -600g/L is categorized as the best black pepper (black pepper no. 1) where as bulk density with 550g/L – 580g/L is categorized as special black pepper. In this case, eventhough all the pepper berries grown under different fertilizer treatment were considered as the best black pepper, but the berries grown under BK 1 and BK2 were considered the best of the best with the bulk density value of 628 g/L anf 627g/ L as compared to BS treatment which is only 595 g/L. A high bulk density value in BK 1 suggested that a more efficient nutrient absorption by pepper vine under this treatment. This might probably due to the existant of organic matter and some benificial microoranisms such as nitrogen fixing microbes, phosphate solubilizing microbes, photosynthetic microbes and etc.

Table 4: Effect of different fertilizer treatment on physio-chemical properties of pepper berries. BK1: Bio-chemical fertilizer (15:5:14) fertilizer treatment, BK 2: Bio-chemical fertilizer (13:4:12) fertilizer treatment, and BS: chemical fertilizer treatment

Sample	Moisture content (%) v/w	Volatile oil (%) v/w	Piperine (%) w/w	Non volatile ethyl extract (NVEE) (%) w/w	Light berries (%) w/w	Bulk Density g/L
BK 1	12.19b	5.48a	8.47a	8.74a	0.35b	628a
BK 2	13.00a	5.45a	8.63a	8.86a	0.44b	627a
BS	13.49a	4.83b	7.63b	8.33a	1.17a	595b

Means in column with different letters are significantly different at 0.05 level using Duncan Multiple Range Test.

3.3 Pepper yield

The dry weight of pepper berries per plot over the years were significantly different among the treatments (Table 5). The yield of dry white pepper berries grown under BK 1 treatment (6.02 t ha^{-1})) was higher than those grown under BK2 (5.08 ton/ ha^{-1}/ year) and BS fertilizer treatment (4.72 ton/ ha^{-1} /year). These results are in accordance with Alam et al., 2005 [16], who reported that enhancement of crop yield through the integrated fertilizer regime (application of organic and chemical fertilizer). This study found BK1 fertilizer treatment to increase pepper yield by 18.5% and 27.5% compared to BK1 and BS fertilizer treatment. Besides, this finding is also in comformity with the findings reported earlier that BK 1 fertilizer able to increase the size and reduce the light berries content in pepper. In term of average number of fruit spike/vine, no significant different was observed. This finding may be due to sufficient nutrient being applied to all the treatment at the flowering stage.

Table 5: Effect of fertilizer treatments on yield of pepper. BK1: Bio-chemical fertilizer (15:5:14) fertilizer treatment, BK 2: Bio-chemical fertilizer (13:4:12) fertilizer treatment, and BS: chemical fertilizer treatment

Treatment	Yield / vine (kg/vine/year)	Yield / hectare (ton/ha^{-1}/ yr)	Average no of fruit spikes/vine
BK 1 (15:5:14)	3.01a	6.02a	894.26±128a
BK 2 (13:4:12)	2.54b	5.08b	886±125a
BS (12:12:17)	2.36b	4.72c	874±113a

Means in column with different letters are significantly different at 0.05 level using Duncan Multiple Range Test.

3.4 Leaf characteristics

The leaf canopy architecture of pepper vine is an important growth character for determining vigor and productivity of black pepper. At the individual plant level, the pepper vine planted under different fertilizer treatments affected the leaf characteristic of pepper genotypes. No significant different in term of mean and total leaf area of pepper vinegrown under different fertilizer treatment. This indicated that sufficient nutrient was applied to pepper vine during the growth and production stage. This finding were further supported by Laghari *et al*., (2010) [17]who reported that increase in the area of leaf is a common response of leaves that absorb appropriate amount of nutrients. The finding may be due to specific leaf area (cm^2/g) increasing with increasing nutrients availability (Table 6), as has been seen in other crop e.g. wheat [17] and rice [18]. From the data obtained, the mean LAI of pepper grown under the BK1 and BK 2 fertilizer treament (5.62 and 5.52 respectively) were higher than those grown under chemical fertilizer treatment (4.93). This finding is expected as there is a significant drop of soil pH after long term application of chemical fertilizer. This phenomenon will lead to pepper vine experiencing nutrient deficiency and finally causeleaf, branch and twig drop.

Table 6: Effect of different fertilizer treatment on leaves after harvesting. BK1: Bio-chemical fertilizer (15:5:14) fertilizer treatment, BK 2: Bio-chemical fertilizer (13:4:12) fertilizer treatment, and BS: chemical fertilizer treatment

Fertilizer treatments	LAI	Mean leaf area (cm^2)	Total leaf area (cm^2)
BK1	5.62a	19.7a	195.5a
BK 2	5.52a	19.1a	189.9a
BS	4.93b	18.9a	200.7a

Means in column with different letters are significantly different at 0.05 level using Duncan Multiple Range Test.

3.5 Chlorophyll content and photosynthesis rate

It was reported that availability of nutrient in soil significantly affect the photosynthetic rate (Pn), chlorophyll (Chl) and transpiration in pepper vine [18,19]. From the analysis, net photosynthetic rate was markedly higher for plant grown under BK 1 treatmentalthough there were no significant different between BK1, BK 2 and and chemical fertilization treatment(Table 7). This observation was supported by the finding of Okali and Owusu (1975) [20] who reported that net photosynthetic rate was highest in plant that maintained at the highest nutrients level. The high photosynthetic rates were mainly due to a greater chlorophyll content as well as the availability of nutrients to plants.

Chlorophyll content is of particular significance in precision agriculture as an indicator of photosynthesis activity [21]. There is a strong linear relationship between nutrients availability and chlorophyll content according to Sabo *et al*., (2002) [22] and Bojovic and Stojanovic, (2005) [23]. It was observed that pepper crop grown under all fertilizertreatment had dark green leaves, higher chlorophyll content and a higher chlorophyll a/b ratio. This indicated that better nutrient supply received by pepper vine under all fertilizer treatment as this chlorophyll is believed to take part in the process of organogenesis [23]. Previous report also support our finding that lighter green leaves, unless experiencing low light condition (shading), have reduced total chlorophyll/mg fresh weight and higher chlorophyll a/b ratio [24, 25].

Concomitantly, analysis results also showed that chemical fertilizater treatment has a higher transpiration rate than pepper grown under BK 1 and BK2 fertilizer treatment (T3) (Table 7). The ratio of photosynthesis to transpiration (instantaneous water use efficacy) was accordingly higher in BK 1 fertilizer treatment, with the loss of one m mol of water, 5.33 and 5.05 and 3.55 µmol of CO_2 was fixed inpepper vine grown under, BK 1, BK 2 and BS fertilizer treatment, respectively. High photosynthetic rate with lower CO_2 concentration inside the sub-stomata cavity in BK 1 fertilizer treatment suggested a more efficient carboxylation system (Table 7). The instantaneous water use efficacy of the leaf (represented by the ratio of photosynthesis to transpiration) is a measurement of carbon gained through photosynthesis with per-unit water transpired. A higher photosynthetic rate with lower transpiration in BK 1fertilier treatment indicates that water was used more efficiently than cehmical fertilizer treatment.

Table 7:Comparison of chlorophyll content, transpiration rate, net photosynthesis and internal CO_2 concentration with different fertilizer treatments. BK1: Bio-chemical fertilizer (15:5:14) fertilizer treatment, BK 2: Bio-chemical fertilizer (13:4:12) fertilizer treatment, and BS: chemical fertilizer treatment

Parameters	Fertilizer treatment		
	BK 1	Bk 2	BS
Chlorophyll a (mg g^{-1} FW)	3.15a	3.03a	2.85b
Chlorophyll b (mg g^{-1} FW)	1.24a	1.26a	1.10a
Total Chlorophyll	4.39a	4.29a	3.95b
Net photosynthesis rate (µ mol m^{-2} S^{-1})	28.77a	28.38a	24.26b
Transpiration (m mol m^{-2} S^{-1})	5.39b	5.62b	6.83a
Internal CO_2 concentration (ppm)	254.8b	248.1b	305.6a

Means in row with different letters are significantly different at 0.05 level using Duncan Multiple Range Test.

3.6 Foliar nutrient content

The foliar nutrient content of pepper vine under different fertilizer treatment is presented in Table 8. It was observed that there were no significant different between all the fertilizer treatment. This indicated that the nutrient applied might be the optimal fertilizer schedule for black pepper. According to the content range defined by Sadanandan et al, 2000 [26], pepper nutrition planted under integrated and chemical treatments was in the sufficient range. No case of deficiency was recorded.

Table 8: Foliar nutrient content of pepper with different fertilizer treatments. BK1: Bio-chemical fertilizer (15:5:14) fertilizer treatment, BK 2: Bio-chemical fertilizer (13:4:12) fertilizer treatment, and BS: chemical fertilizer treatment

Treatment	Nutrient concentration (%)				
	Total N	Total P	Total K	Total Mg	Total Ca
BK 1	2.41a	0.146a	2.79a	0.32a	1.44a
BK 2	2.63a	0.139a	2.95a	0.31a	1.27a
BS	2.57a	0.150a	2.65a	0.31a	1.30a

Means in row with different letters are significantly different at 0.05 level using Duncan Multiple Range Test.

3.7 Effect of fertilizer treatment of soil fertility

Table 9 showed the influence of different fertilizer treatments on soil chemical properties. The plots applied with biochemical fertilizer significantly increased the soil pH after cropping except for application of chemical fertilisers. The effect of soil acidification is mainly due to high fertiliser levels. This research finding agreed with work of Ayoola (2006) [14], who reported that that application of a high level of chemical fertilizer as the main factor for reducing soil pH in a cassava-based cropping system. These findings were further confirmed by the observation of soil acidity symptoms on pepper leaves (Figure1).

The level of organic C were found to be highest in BK 2 (1.53), followed by BK1 (1.46) whereas chemical fertilizer tratment (BS) having the lowest organic carbon percentage with the value of 0.95. This showed that incorporation of organic matters into the soil could be an efficient way of maintaining desired soil organic matter level. Table 8 showed that no significant different were observed for the percent of total nitrogen in all the fertilizer treatment. This indicated that all the treatment plots having sufficient nitrogen source plot for growth and production.

The availability of phosphorus was highest in plants with BK 1 fertilizer treament (952) compared to that from BK 2 (870) and chemicalfertilizer treatment (788). These results proved that the utilisation of fertilizer incorpoated with chemical and organic fertilisers could supply the plants with good amounts of available phosphorus. The highest CEC value was obtained by BK 2 treatment (9.2) followed by BK 1 fertiliser treatment (9.1) cmol $_{(+)}$ kg^{-1},respectively), while the lowest value (7.6) was observed by chemical fertiliser treatment. The highest CEC value observed in BK 2 treatment indicated those nutrients were highly retained compared to those from other treatments. The BS fertilizer treatment had the highest exchangeable cation potassium (3.53 me/100g) which was significantly higher than in all other treatments (3.83, and 2.95 me/100g for BK2 and BK 1 treatment (Table 8). The high exchangeable cation potassium in the chemical fertilizer treatment indicated that this element was in excessive amount and has been overused for pepper production. In term of exchangeable Mg and Ca, BK2 having the highest value (3.38 and 6.47 me/100g), followed by BK1 (2.52 and 4.52 me/100g respectively). Chemical fertilizer treatment, BS having the lowest reading with exchangeable value for magensium was 1.72 and 1.90 me/100g respectively. This finding is in accordance with the report published by Yap (2012) [3] which states that the pepper crop only requires 390-62-352-47-100 kg/ha of N-P-K-Mg-Ca per year in order to sustain the growth and production of pepper berries.

Table 9: Nutrient status in soil after treatment. BK1: Bio-chemical fertilizer (15:5:14) fertilizer treatment, BK 2: Bio-chemical fertilizer (13:4:12) fertilizer treatment, and BS: chemical fertilizer treatment

Treatment	pH	OC	CEC	Nutrient concentration (%)				
		(%)	(cmol (+) kg^{-1}	N	P	Exc. K	Exc. Mg	Exc. Ca
BK 1	5.21a	1.46a	9.1a	0.22a	952a	2.95b	2.52b	4.52b
BK 2	5.09a	1.53a	9.2a	0.23a	870ab	3.83a	3.38a	6.47a
BS	4.38b	0.95b	7.6b	0.23a	788b	3.53a	1.72c	1.90c

Means in row with different letters are significantly different at 0.05 level using Duncan Multiple Range Test.

Figure1: Soil acidity symptom

4.0 Conclusion

It is well known that long term fertilizer application with organic materials improves physical, chemical and biological properties of soils [27]. Up to now, there have been several studies done on organic fertilizer [28,29, 30]. However, the application of organic fertilizer only has led to poor growth performance of pepper as well as a reduction of 70% of pepper yield annually [3]. Therefore, for sustainable crop production, the application of biochemical fertilizer (15:5:14) is a more viable option. On the basis of aforementioned results, it is suggested that biochemical fertilizer (15:5:14) is a good fertilizer for black pepepr. This fertilizer not only able to enhance the growth of pepper vine, but also able to increase the production by increasing the berries size, reduce the light berries as well as increase the pepper quality and the soil physio-chemical properties of surrounding soil.

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