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Research Article

The Economics of Using Phosphate Rock under Matured Oil Palm in the Semi-deciduous Forest Zone in Ghana

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Abstract: The aim of the study was to find out the economic suitability of using phosphate rock under matured oil palm in the semi-deciduous forest zone in Ghana. The study was conducted between 2002 and 2007 at the Oil Palm Research Institute at Kusi, Ghana. The oil palm trees selected were 8 year old tenera (DXP ex OPRI). Each plot measured 17.6 m×17.6 m. There were four treatments, consisting of: 1). TSP-control: 222 kg of AS+222 kg of TSP+296 kg of MOP/ha/yr- OPRI fertilizer recommendation; 2). PR1-PR 715 kg+222 kg of AS+296 kg of MOP/ha-Yr 1. PR 358 kg+222 kg of AS+296 kg of MOP/ha-Yr 2. PR358 kg+222 kg of AS+296 kg of MOP/ha-Yr 3; 3). PR2-PR 1428 kg+222 kg of AS+296 kg of MOP/ha applied once in every 5 years; 4). PR3- PR 142.85 kg/ha+222 kg AS/ha+296 kg of MOP/ha applied twice in every 5 years. The cost-benefit analysis was carried out by comparing production cost and revenue for triple super phosphate and phosphate rock regimes. The cost benefit ratio in a declining order were: 3.4, 3.1, 2.9 and 2.4 for PR3, PR2, PR1 and TSP, respectively. The study has clearly shown that, economically it is sound to use PR under matured oil palm.

Keywords: Cost-benefits, phosphate rock, semi-deciduous, triple super phosphate and oil palm

INTRODUCTION

Increased population pressure, reduced length of fallow, deforestation and improper agricultural practices have led to widespread soil degradation in many parts of the developing world including Ghana (Smaling *et al*., 1997). An important manifestation of this environmental damage is the inadequate replenishment of soil nutrients and organic matter. In particular, phosphorus (P) deficiency has become critical in many soils. Moreover, because of complementarities in the uptake of plant nutrients, this deficiency threatens to disturb the viability of applying other nutrients. Oil palm is a heavy feeder for macronutrients, especially N, P and K and phosphate deficiency may be sufficiently acute to produce foliar symptoms (Ahuja *et al*., 2007). Among others, increasing fertilizer costs and environmental pollution are the problems of major concern needing an urgent attention. The cost of purchasing fertilizers is in the order P>K = N>S (FAO, 2004), indicating that fertilizer cost will be largely determined by the amount of P purchased (Hardy and Osmond, 2006).

The efficiency and sustainability of added P to weathered and highly acidic soils for tree crop nutrition (oil palm) partially depend on the types of material used (Ayaga *et al*., 2006). The most common fertilizers are superphosphates in the tropics and Phosphate Rocks (PRs) in the Far East (Hartley, 1988). Application of P fertilizer sources, especially those with a significant content of less soluble P such as PR, can be considered as restoration of natural resource base. This is because it augments and maintains the stock of P capital embodied in soil resources. In this respect, PR is to be seen as an amendment that improves the soil nutrient status with farmers benefiting from increased agricultural output and decreased nutrient depletion (Gerner and Baanante, 1995). Case studies of PR application in Burkina-Faso, Madagasca, Mali and Zimbabwe (World Bank, 1997) show that farm level rate of return can be highly attractive for various crops with oil palm being inclusive and even more so when the environmental impact on society at large are included.

The oil palm industry is now booming with palm and palm kernel oil commanding high prices in the global market due to its use as biodiesel and other petrochemical products. Despite all these, expansion appears to have slowed down owing to high initial investment costs. There is therefore an urgent need to search for alternative sources of P at affordable cost to both small-scale oil palm farmers and commercial estate developers. Furthermore, there is lack of information on the cost-benefit analysis of using PR under oil palm. This study, therefore, attempts to

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evaluate PR economic benefit in oil palm cultivation in semi-deciduous forest zone in Ghana.

MATERIALS AND METHODS

Experimental design and treatments: The experiment was conducted in Randomized Complete Block Design (RCBD) with 4 treatments in 3 replications. It was carried out at the CSIR- Oil Palm Reasearch Institute between 2002 and 2007. The oil palm trees selected were 8 year old tenera (DxP ex OPRI). Each plot measured 17.6 m×17.6 m. Planting was done at a spacing of 8.8 m triangular or the equivalent of 148 palms per hectare. The treatments evaluated were as follows:

TSP-Control-222 kg of AS+222 kg of TSP+296 kg of MOP/ha/yr (equivalent to 46 kg N+102 kg P_2O_5 + 177 k g K_2O/ha/yr) -OPRI fertilizer recommendation

PR1-PR 715 kg+222 kg of AS+296 kg of MOP/ha/yr (equivalent to 200 kg P_2O_5 +46 kg N+177 kg K2O/ha) -Yr 1 PR 358 kg+222 kg of AS+296 kg of MOP/ha (equivalent to 100 kg P_2O_5+46 kg N+177 kg K_2O/ha) -Yr 2 PR 358 kg+222 kg of AS+296 kg of MOP/ha (equivalent to 100 kg P_2O_5+46 kg N+177 kg K_2O/ha) -Yr 3

PR2-PR 1428 kg+222 kg of AS+296 kg of MOP/ha (equivalent to 400kg P_2O_5 +46 kg N+177 kg K_2O/ha) applied once in every 5 years.

PR3-PR 142.85 kg/ha+222 kg AS/ha+296 kg of MOP/ha (equivalent to 40 kg P_2O_5, 46 kg N and 177 kg K_2O) applied twice in every 5 years.

(In the above treatments, AS = Ammonium Sulphate, TSP = Triple Super Phosphate, MOP = Muriate of Potash and PR = Phosphate Rock).

Treatment plots were broadcasted with appropriate straight fertilizers individually within the interrows and rings of palm trees (1.5 m radius around the palm). These fertilizers were later worked into a depth of about 3 cm to ensure better contact with soil particles.

Crop management: For effective growth and development of palms, the following management practices were carried out as and when necessary.

Cover cropping: Plots were cultivated with leguminous cover crop *Pueraria phaseoloides* at a seeding rate of 0.5 kg per plot. This was to check erosion, keep soil friable, improve soil structure, reduce leaching and suppress weeds.

Pruning: Judicious removal of non-functional fronds was carried out annually with a pruning cutlass. Pruning provided ready assess for harvesting and reduced the loose fruits trapped in the frond bases.

Diseases and pest control: Phytosanitary inspectors routinely carried out visits to site to control pest and disease.

Weed control: Both ring weeding and interrow brushing were carried out quarterly. Ring weeding was done with a cutlass 1.5 m radius around the palm base. Interrow brushing was also carried out to lessen competition between palms and weeds.

Agroeconomic analysis: The cost benefit analysis of treatments was carried out, over the period 2004-2007 after the imposition of treatments by comparing production cost and revenue generated by triple superphosphate (control) with PR treatments. Total cost (X) was calculated as: X = a+b+c+d+e+f, where variables a, b, c, d, e and f were:

a. Land preparation
b. Linning and pegging
c. Planting materials and planting
d. Rolls of wire collars and fixing
e. Cost of harvesting and transportation
f. Maintenance cost (weeding and fertilization)

The economic yield of the produce during the period was multiplied by the price as pertained at the sales point of CSIR-OPRI. Cost was deducted from the revenue to indicate whether there was a loss or profit:

Benefit = Revenue-Cost

The cost benefit ratio, which is the return per cash invested, was calculated by dividing gross income by total cost of production:

Cost benefit ratio = (Revenue generated/Total cost of production)

Income Equivalent Ratio (IER): This is the relative area under OPRI fertilizer recommendation (control) required to produce the income achieved in PR treated plots. It was therefore calculated using the control as the basis for comparism.

RESULTS

Establishment cost: Cost of establishing one hectare of oil palm with the cover crop *pueraria phaseoloides* amounted to about one hundred and thirty Ghana cedis, sixty pesewas (GH¢130.6) (Table 1).

Upkeep, fertilization, harvesting and transportation cost: Table 2 presents upkeep, fertilization, harvesting and transportation cost for treatments. The cost of operations for the plots that received TSP (control) was GH¢ 197.7 in 2004. This increased to about GH¢ 227.8, GH¢ 253.2 and GH¢ 326.3 for the year 2005, 2006 and 2007, respectively.

Plots that received PR included PR1, PR2 and PR3 and the respective cost incurred were GH¢ 288.5, GH¢ 311.9 and GH¢ 164.3 for the year 2004. The cost values decreased and increased marginally for 2005 and 2006,

Table 1: Establishment cost of one hectare of oil palm plantation

Item	Mandays	Quantity	Unit cost (GH¢)	Cost/ha (GH¢)
1. Land preparation:				
a) Under brushing	12		0.5	6.0
b) Felling	18		0.5	9.0
c) Chopping down crown	15		0.5	7.5
d) Cutting fire belt, burning, Heaping and 2nd burning	9		0.5	4.5
2. Linning and pegging including cutting of pegs	8		0.5	4.0
3.Cutting and fixing of collars	4		0.5	2.0
3. Planting/sowing:				
a) Oil palm DXP seedlings	3		0.5	1.5
b) Pueraria Seeds	3			
4. Cost of planting materials				
a) Oil palm DXP seedlings		148	0.35	51.8
b) Pueraria seeds		6.5 kg	0.32	2.0
5. Transportation of seedlings (5 km radius)				20.8
6. Rolls of wire collars		4	9.7	38.8
Total				130.6

Table 2: Upkeep, fertilization, harvesting and transportation cost per hectare of oil palm

	GH¢				
	2004	2005	2006	2007	Total
1. Oil palm labour requirement					
a. Ring weeding	25.5	27.5	30.0	32.0	115.0
b. Interrow weeding	30.0	30.0	35.0	40.0	135.0
c. Fertilizer application	25.5	27.5	30.0	32.0	115.0
d. Harvesting and pruning	35.0	40.0	50.0	50.0	180.0
e. Transportation of Fresh Fruit Bunches	20.0	25.0	30.0	30.0	105.0
2. Fertilizer requirement					
a. Rock phosphate	84.4	84.4	84.4	84.4	337.6
b. Triple Superphosphate	66.0	79.9	124.3	177.6	448.4
c. Muriate of Potash	53.3	75.4	111.1	155.4	395.2
d. Ammonium Sulphate	53.0	75.4	124.3	155.4	408.4

Table 3: Yield from various treatments

	T/ha				
Treatment	2004	2005	2006	2007	Total
TSP (control)	13.50	13.53	16.76	9.93	123.50
PR1	16.00	14.70	18.61	11.67	130.70
PR2	13.80	17.30	18.88	12.80	132.50
PR3	16.90	12.60	17.56	11.23	128.00

Table 4: Annual revenue from fresh fruit bunches of various treatments

	GH¢				
Treatment	2004	2005	2006	2007	Total
TSP (control)	621.0	608.9	754.2	794.4	2778.5
PR1	736.0	661.5	837.5	933.6	3168.6
PR2	634.8	760.5	778.5	1024	3197.8
PR3	777.4	567.0	790.2	898.4	3033.0

Table 5: Economic evaluation of oil palm as influenced by treatments

	GH¢				
Treatment	TCP	GI	NI	RCI	IER
TSP (control)	1135.6	2778.5	1642.9	2.4	1.0
PR1	1084.5	3168.6	2084.1	2.9	1.1
PR2	1016.4	3197.8	2181.4	3.1	1.2
PR3	882.6	3033.0	2150.4	3.4	1.1

respectively. In 2007 the cost incurred on PR treated plots received a further increase. The increases recorded in 2007 for treatment PR1, PR2 and PR3 values were GH¢ 284.1, GH¢ 241.9 and GH¢ 254.7, respectively.

Yield and annual revenue generated from the sales of fresh fruit bunches are presented in Table 3 and 4 respectively. Prices of fresh fruit bunch fluctuated based on the world market price of crude palm. Total revenue generated for the treatments were in the increasing order of GH¢ 2,778.5, GH¢ 3,033.0, GH¢3,168.6 and GH¢3,197.8 for TSP, PR3, PR1 and PR2, respectively.

Economic evaluation of using PR under oil palm:

During the period of the trial: The least gross income of GH¢2,778.5 was generated from plots that received TSP application (control) and this was enough to offset the production cost of GH¢1,135.6 (Table 5). Plots that received PR of 1428 kg/ha once in 5 years (PR2) gave the highest net income of GH¢3,197.8 and return per cash invested was 3.1. The economic returns or return per cash invested for the treatments during the period of study were in the order of PR3>PR2>PR1>TSP.

In the above economic evaluation (Table 5), TCP = Total Cost of Production, GI = Gross Income, NI = Net Income, RCI = Return Per Cash Invested and IER = Income Equivalent Ratio. Using TSP (control) as the basis for comparism, income equivalent ratio for TSP, PR1, PR2 and PR3 were 1.0, 1.1, 1.2 and 1.1 respectively.

DISCUSSION

According to Gerner and Baanante (1995), PR application by farmers is sustainable when it is profitable, socially acceptable and environmentally friendly. The cost benefit analysis of the trial during the period in increasing order for the various treatments were 2.4, 2.9, 3.1 and 3.4 for TSP, PR1, PR2 and PR3 respectively. There were higher net profit returns for the entire PR treatments than TSP treatment (control). The PR2 recorded a net profit of about GH¢ 2,181.4 and this was enough to re-invest about three times into the same project. The net income from the remaining PR treatments, PR1 and PR3 could offset about three times and three and half times of the total cost of production respectively. The least attractive treatment was recorded for TSP treated plots (control). This was due to the high cost of the TSP component in the fertilizer applied. These results support the study conducted by Dahoui (1994), who concluded that the total cost per unit of P_2O_5 in PR is approximately half the cost per unit of P_2O_5 in TSP. The economic evaluation of PR under oil palm has also been carried

out by Zin *et al*. (2005) in Malaysia. They observed that the return of cash invested in PR was better than TSP. During the period, PR2 could be considered as the most attractive for farmers in terms of profit as it exceedingly reduced the production cost. Despite the fact that the net income from PR3 was close to PR2, farmers will always opt for PR2 since additionally, it insulates them from market uncertainties and has an important advantage associated with time management (where the application of PR was done once in five years).

CONCLUSION

The cost benefit analysis in increasing order were 2.4, 2.9, 3.1 and 3.4 for TSP, PR1, PR2 and PR3 respectively. All the phosphate rock regimes gave better positive net revenue by 2007 than triple super phosphate (control). The study has clearly shown that, economically it is sound to use phosphate rock under matured oil palm instead of super phosphates.

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