*Short Communication*

# THE ECONOMICS OF THE USE OF INORGANIC FERTILISERS AND FARM YARD MANURE IN THE PRODUCTION OF IRISH POTATOES (*SOLANUM TUBEROSUM L.*)

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***Abstract***

*Arable land in Kenya is decreasing as a result of population pressure, therefore there is need to increase production per unit area. Potato (Solanum tuberosum L.) being a heavy feeder of plant nutrients in the soil requires high supply of external mineral nutrients in the form of inorganic fertilisers or organic manure. Decline in soil fertility and high cost of inorganic fertilisers are limitations to potato yield improvement in Kenya. Potato (Variety 'Asante') was planted for 2 seasons at National Agricultural Research Center – Kitale and one season at Psigirio village (West Pokot District) during 2002 and 2003. The experimental design was Randomized Complete Block (RCB) laid in a Split-plot arrangement with three replications. The potassium levels (0, 83 and 166 K kg ha$^{-1}$) formed the main plots, while phosphorus (0, 52 and 100 P kg ha$^{-1}$) and farmyard manure (0, 10 and 20MT FYM ha$^{-1}$) combinations formed the sub plots. Cost-Benefit-Ratios (CBR) was computed to assess the profitability of treatments. The highest CBR was realized in the application of 100 P kg ha$^{-1}$ at NARC - Kitale season 1, 50 Kg P ha$^{-1}$ + 20 t FYM ha$^{-1}$ at NARC - Kitale season 2 and the application of 83 kg K ha$^{-1}$ + 50 kg P ha$^{-1}$ at the Psigirio site. Results indicated that the combined use of inorganic fertiliser and manure is feasible option for soil fertility improvement for potato production. The main objective of the study was to assess the potential for producing high potato yields through use of farmyard manure with reduced quantities of phosphorus and potassium fertilizers..*

**Key words:** potato *Solanum tuberosum*, farmyard manure, inorganic fertilizers, benefit cost ratio

## INTRODUCTION

Potato is an important horticultural crop worldwide used as human food as well as animal feed. In Kenya, potato is ranked as the highest horticultural crop in terms of hectarage accounting for 108 516 ha, yielding 670 303 t (MOA & RD, 2000). The tubers are boiled, steamed, baked, roasted, or fried.

The use of FYM on low value crops, such as maize, is not as economical as when used on high value crops, such as, potatoes. Therefore, there is need to encourage the use of organic manure on high value crops as opposed to the low value ones. However the economics for the use of organic/inorganic fertilizers in potato production is of great importance. Cost benefit ratio (CBR) which can be defined as the total discounted benefit divided by the total discounted cost (Kruse, 2004) is an important parameter since it determines the viability of a project. The project is considered viable if, and only if the CBR is greater than one (Miller, 2001)

The hypothesis tested in this study was: Farmyard manure and inorganic fertilizers use on potato production have no effect on Cost Benefit Ratio (CBR) and the net returns. The objectives of the study was to assess the potential for producing high potato yields through use of farmyard manure with reduced quantities of inorganic fertilizers and determine the highest Cost Benefit Ratio (CBR) and the net returns of using FYM and inorganic fertilizers for potato production.

## MATERIALS AND METHODS

The study was carried out in 2002 and 2003 at two sites; Kenya Agricultural Research Institute (KARI) - Kitale and a farmer field school established at Psigirio village in West Pokot District, rift valley province of Kenya. KARI-Kitale lies at a longitude of 35$^{o}$ 7.5' E, latitude of 1$^{o}$ N and 1890 m above the sea level. The area receives an average rainfall of 1182- mm P.a. The soil type is Rhodic Ferrasols which are well-drained, very deep, dark to dark red, very friable to friable clay, with a pH of 6.8. The mean temperature is 18.3$^{o}$C (Jaetzold and Schmidt, 1983).

Psigirio site lies at a longitude of 35$^{o}$ 15' E and a latitude of 1$^{o}$ 15' N and 2000 M above the sea level. The area receives an average rainfall of 1289-mm P. a. The soil type is Humic Cambisols and Humic Acrisols which are well drained, moderately deep to deep, dark reddish brown to brown, friable to firm, sandy clay loam to clay, with a pH of 6.8 and a mean temperature of 16.3$^{o}$C (Jaetzold and Schmidt, 1983).

The experimental design was randomized complete block design (RCB) in a split plot arrangement, with three replications. The potassium (K) rates (0 K kg ha$^{-1}$, 83 K kg ha$^{-1}$, and 166 K kg ha$^{-1}$), formed the main plot whereas the phosphorus (P) /FYM combinations formed the sub-plots. Nine treatments of phosphorus and farmyard manure either singly or in combination were used. The P rates were 0, 50, and 100 kg P kg ha$^{-1}$, while FYM rates included 0, 10 and 20 t ha$^{-1}$. The

treatments were control, 10 t FYM $ha^{-1}$, 20 t FYM $ha^{-1}$, 50 kg P kg $ha^{-1}$, 50 kg P kg $ha^{-1}$ + 10 t FYM $ha^{-1}$, 50 kg P kg $ha^{-1}$ + 20 t FYM $ha^{-1}$, 100 kg P kg $ha^{-1}$, 100 kg P kg $ha^{-1}$ + 10 t FYM $ha^{-1}$, 100 kg P kg $ha^{-1}$ + 20 t FYM.

Potato variety 'Asante' the most preferred in the two sites (Nandasaba et al., 1999) was used in this trial. The plot size used was 3m x 3m and the potatoes were planted at a spacing of 75cm x 30cm (five rows per plot and eleven plants per row). The inorganic source fertilisers used were triple supper phosphate (TSP), muriate of potash (KCl) and nitrogen (N) applied as calcium ammonium nitrate (CAN) at the rate of 75 kg N $ha^{-1}$ uniformly to all plots five weeks after emergence, whereas the organic source was farmyard manure (FYM). The manure was spread in the respective plots immediately after ploughing, and then incorporated into the soil. For the inorganic fertiliser, triple supper phosphate (TSP, phosphorus source) and Muriet of potash (MOP, potassium source) were drilled along the furrows at planting but calcium ammonium nitrate (CAN) applied as a top dress five weeks after emergence.

Economic analysis (Cost-Benefit-Ratio) was done to assess the profitability of various fertilizer combinations. The Cost Benefit Ratio (CBR) was calculated using the formula:

CBR = (Gross income–Variable Cost)/Variable cost (Upton 1987). Partial budget was performed in order to ascertain the net income of the treatments.

**Assumptions made In the calculations of The Cost Benefit Ratios:**

50 kg TSP cost Ksh. 1,250
50-kg MOP cost Ksh. 1,300
1 ton FYM cost Ksh. 1,000
Ploughing cost Ksh. 3,000 $ha^{-1}$
1 ton potato seed sells @ Ksh.10, 000
Ridging cost Ksh. 1,250 $ha^{-1}$
100-kg potato seed @ Ksh. 2,000
Planting cost Ksh. 5,000 $ha^{-1}$
Earthing up cost Ksh. 4,000 $ha^{-1}$

## RESULTS AND CONCLUSION

From the Partial budgeting done, The results showed that at KARI- Kitale season 1 trial, the highest CBR was realized at the application of 100 P kg $ha^{-1}$ (without K and FYM) and the lowest at the application of 83kg K $ha^{-1}$ + 100 P kg $ha^{-1}$ +10t FYM $ha^{-1}$ (Table 1). At the KARI - Kitale season 2, the highest CBR was realized at the application of 166 K kg $ha^{-1}$ + 100 P kg $ha^{-1}$ + 10t FYM $ha^{-1}$ and the lowest CBR was realized in the control treatment (Table 2). At Psigirio, the highest CBR was realized at the application of 100 P kg $ha^{-1}$ 10 t FYM $ha^{-1}$ with no application of K and the lowest in the control treatment (Table 3).

In the second season (KARI - Kitale) and Psigirio, at all levels of K application, treatments without Phosphorus and FYM, showed the lowest CBR. Though less amounts of money was used in cases where no fertilizer is applied, low yields are realized which is translated to lower monetary gain hence low cost benefit ratios are realized. The high costs experienced at higher levels of fertilizer applications are nullified by high income realized. In Tables 1, 2 and 3, treatments with CBRs greater than 2 (underlined) shows that the treatment is worthwhile being undertaken in potato production.

## CONCLUSION

The best CBR and the net returns were realized in treatments having 0 kg K $ha^{-1}$+ 100 P kg $ha^{-1}$ + 10t FYM $ha^{-1}$ for the KARI - Kitale season 1, 0 K kg $ha^{-1}$+ 50 Kg P $ha^{-1}$ + 20t FYM $ha^{-1}$ for NARC - Kitale season 2 and finally the application of 83 kg K $ha^{-1}$ + 50 kg P $ha^{-1}$+ 0 MT FYM $ha^{-1}$ or the on farm site.

**Recommendation**

From the economic analysis done, the combination of small quantities of potassium, FYM and phosphorus is recommended for production high yields of potatoes.

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**Tab. 1:** Economic analysis season 1 KARI – Kitale, 2002

| Treatment | | Yield (Y) (t/ha) | Price (P) Ksh/t | Gross income (GI) (Ksh.) | Variable cost (VC) (Ksh.) | Net benefit (NB) (Ksh.) | CBR |
|---|---|---|---|---|---|---|---|
| Main plot | Sub plot | | | Y × P | | GI – VC | NB/VC |
| 0 kg K/ha | 1 | 27.26 | 10 000 | 272 600 | 50 000 | 222 600 | 4.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 kg K/ha | 2 | 32.77 | 10 000 | 327 700 | 60 000 | 267 700 | 4.5 |
| 0 kg K/ha | 3 | 28.15 | 10 000 | 281 500 | 70 000 | 211 500 | 3.0 |
| 0 kg K/ha | 4 | 33.30 | 10 000 | 333 000 | 56 250 | 276 750 | 4.9 |
| 0 kg K/ha | 5 | 32.61 | 10 000 | 326 100 | 66 250 | 259 850 | 3.9 |
| 0 kg K/ha | 6 | 35.85 | 10 000 | 358 500 | 76 250 | 282 250 | 3.7 |
| 0 kg K/ha | 7 | 43.33 | 10 000 | 433 300 | 62 500 | 370 800 | 5.9 |
| 0 kg K/ha | 8 | 34.50 | 10 000 | 345 000 | 72 500 | 272 500 | 3.8 |
| 0 kg K/ha | 9 | 28.64 | 10 000 | 286 400 | 82 500 | 203 900 | 2.5 |
| 83 kg K/ha | 1 | 26.87 | 10 000 | 268 700 | 56 500 | 212 200 | 3.8 |
| 83 kg K/ha | 2 | 30.21 | 10 000 | 302 100 | 66 500 | 235 600 | 3.5 |
| 83 kg K/ha | 3 | 28.03 | 10 000 | 280 300 | 76 500 | 203 800 | 2.7 |
| 83 kg K/ha | 4 | 31.44 | 10 000 | 314 400 | 62 750 | 251 650 | 4.0 |
| 83 kg K/ha | 5 | 25.36 | 10 000 | 253 600 | 72 750 | 180 850 | 2.5 |
| 83 kg K/ha | 6 | 27.32 | 10 000 | 273 200 | 82 750 | 190 450 | 2.3 |
| 83 kg K/ha | 7 | 30.71 | 10 000 | 307 100 | 69 000 | 238 100 | 3.5 |
| 83 kg K/ha | 8 | 26.22 | 10 000 | 262 200 | 79 000 | 183 200 | 2.3 |
| 83 kg K/ha | 9 | 36.18 | 10 000 | 361 800 | 89 000 | 272 800 | 3.1 |
| 166 kg K/ha | 1 | 26.34 | 10 000 | 263 400 | 63 000 | 200 400 | 3.2 |
| 166 kg K/ha | 2 | 32.82 | 10 000 | 328 200 | 73 000 | 255 200 | 3.5 |
| 166 kg K/ha | 3 | 20.90 | 10 000 | 209 000 | 83 000 | 126 000 | 1.5 |
| 166 kg K/ha | 4 | 25.48 | 10 000 | 254 800 | 69 250 | 185 550 | 2.7 |
| 166 kg K/ha | 5 | 28.93 | 10 000 | 289 300 | 79 250 | 210 050 | 2.7 |
| 166 kg K/ha | 6 | 22.36 | 10 000 | 223 600 | 89 250 | 134 350 | 1.5 |
| 166 kg K/ha | 7 | 24.14 | 10 000 | 241 400 | 75 500 | 165 900 | 2.2 |
| 166 kg K/ha | 8 | 24.20 | 10 000 | 242 000 | 85 500 | 156 500 | 1.8 |
| 166 kg K/ha | 9 | 22.02 | 10 000 | 220 200 | 95 500 | 124 700 | 1.3 |

**Tab. 2:** Economic analysis season 2, KARI – Kitale, 2003

| Treatment | | Yield (Y) (t/ha) | Price (P) Ksh/t | Gross income (GI) (Ksh.) | Variable cost (VC) (Ksh.) | Net benefit (NB) (Ksh.) | CBR |
|---|---|---|---|---|---|---|---|
| Main plot | Sub plot | | | Y × P | | GI – VC | NB/VC |
| 0 kg K/ha | 1 | 8.15 | 10 000 | 81 500 | 50 000 | 31 500 | 0.6 |
| 0 kg K/ha | 2 | 8.83 | 10 000 | 88 300 | 60 000 | 28 300 | 0.5 |
| 0 kg K/ha | 3 | 10.95 | 10 000 | 109 500 | 70 000 | 39 500 | 0.6 |
| 0 kg K/ha | 4 | 16.33 | 10 000 | 163 300 | 56 250 | 107 050 | 1.9 |
| 0 kg K/ha | 5 | 18.16 | 10 000 | 181 600 | 66 250 | 115 350 | 1.7 |
| 0 kg K/ha | 6 | 19.05 | 10 000 | 190 500 | 76 250 | 114 250 | 1.5 |
| 0 kg K/ha | 7 | 17.85 | 10 000 | 178 500 | 62 500 | 116 000 | 1.9 |
| 0 kg K/ha | 8 | 18.97 | 10 000 | 189 700 | 72 500 | 117 200 | 1.6 |
| 0 kg K/ha | 9 | 24.16 | 10 000 | 241 600 | 82 500 | 159 100 | 1.9 |
| 83 kg K/ha | 1 | 9.60 | 10 000 | 96 000 | 56 500 | 39 500 | 0.7 |
| 83 kg K/ha | 2 | 12.71 | 10 000 | 127 100 | 66 500 | 60 600 | 0.9 |
| 83 kg K/ha | 3 | 12.00 | 10 000 | 120 000 | 76 500 | 43 500 | 0.6 |
| 83 kg K/ha | 4 | 22.60 | 10 000 | 226 000 | 62 750 | 163 250 | 2.6 |
| 83 kg K/ha | 5 | 12.90 | 10 000 | 129 000 | 72 750 | 56 250 | 0.8 |
| 83 kg K/ha | 6 | 12.19 | 10 000 | 121 900 | 82 750 | 39 150 | 0.5 |
| 83 kg K/ha | 7 | 21.15 | 10 000 | 211 500 | 69 000 | 142 500 | 2.1 |
| 83 kg K/ha | 8 | 23.85 | 10 000 | 238 500 | 79 000 | 159 500 | 2.0 |
| 83 kg K/ha | 9 | 22.11 | 10 000 | 221 100 | 89 000 | 132 100 | 1.5 |
| 166 kg K/ha | 1 | 9.36 | 10 000 | 93 600 | 63 000 | 30 600 | 0.5 |
| 166 kg K/ha | 2 | 20.38 | 10 000 | 203 800 | 73 000 | 130 800 | 1.8 |
| 166 kg K/ha | 3 | 17.00 | 10 000 | 170 000 | 83 000 | 87 000 | 1.0 |
| 166 kg K/ha | 4 | 22.13 | 10 000 | 221 300 | 69 250 | 152 050 | 2.2 |
| 166 kg K/ha | 5 | 24.37 | 10 000 | 243 700 | 79 250 | 164 450 | 2.1 |
| 166 kg K/ha | 6 | 24.64 | 10 000 | 246 400 | 89 250 | 157 150 | 1.8 |
| 166 kg K/ha | 7 | 27.99 | 10 000 | 279 900 | 75 500 | 204 400 | 2.7 |
| 166 kg K/ha | 8 | 31.03 | 10 000 | 310 300 | 85 500 | 224 800 | 2.6 |

| Treatment | | Yield (Y) (t/ha) | Price (P) Ksh/t | Gross income (GI) (Ksh.) | Variable cost (VC) (Ksh.) | Net benefit (NB) (Ksh.) | CBR |
|---|---|---|---|---|---|---|---|
| Main plot | Sub plot | | | Y × P | | GI – VC | NB/VC |
| 166 kg K/ha | 9 | 29.57 | 10 000 | 295 700 | 95 500 | 200 200 | 2.1 |

**Tab. 3:** Economic analysis on farm 2003

| Treatment | | Yield (MT/ha) | Price (P) Ksh/t | Gross income (GI) (Ksh.) | Variable cost (VC) (Ksh.) | Net benefit (NB) (Ksh.) | CBR |
|---|---|---|---|---|---|---|---|
| Main plot | Sub plot | | | Y ×P | | GI – VC | NB/VC |
| 0 kg K/ha | 1 | 11.26 | 10 000 | 112 600 | 50 000 | 62 600 | 1.3 |
| 0 kg K/ha | 2 | 17.18 | 10 000 | 171 800 | 60 000 | 111 800 | 1.9 |
| 0 kg K/ha | 3 | 18.52 | 10 000 | 185 200 | 70 000 | 115 200 | 1.6 |
| 0 kg K/ha | 4 | 15.23 | 10 000 | 152 300 | 56 250 | 96 050 | 1.7 |
| 0 kg K/ha | 5 | 21.16 | 10 000 | 211 600 | 66 250 | 145 350 | 2.2 |
| 0 kg K/ha | 6 | 26.55 | 10 000 | 265 500 | 76 250 | 189 250 | 2.5 |
| 0 kg K/ha | 7 | 22.24 | 10 000 | 222 400 | 62 500 | 159 900 | 2.6 |
| 0 kg K/ha | 8 | 25.02 | 10 000 | 250 200 | 72 500 | 177 700 | 2.5 |
| 0 kg K/ha | 9 | 32.71 | 10 000 | 327 100 | 82 500 | 244 600 | 3.0 |
| 83 kg K/ha | 1 | 5.07 | 10 000 | 50 700 | 56 500 | –5 800 | –0.1 |
| 83 kg K/ha | 2 | 11.48 | 10 000 | 114 800 | 66 500 | 48 300 | 0.7 |
| 83 kg K/ha | 3 | 15.23 | 10 000 | 152 300 | 76 500 | 75 800 | 1.0 |
| 83 kg K/ha | 4 | 12.03 | 10 000 | 120 300 | 62 750 | 57 550 | 0.9 |
| 83 kg K/ha | 5 | 12.50 | 10 000 | 125 000 | 72 750 | 52 250 | 0.7 |
| 83 kg K/ha | 6 | 19.01 | 10 000 | 190 100 | 82 750 | 107 350 | 1.3 |
| 83 kg K/ha | 7 | 14.62 | 10 000 | 146 200 | 69 000 | 77 200 | 1.1 |
| 83 kg K/ha | 8 | 15.93 | 10 000 | 159 300 | 79 000 | 80 300 | 1.0 |
| 83 kg K/ha | 9 | 27.91 | 10 000 | 279 100 | 89 000 | 190 100 | 2.1 |
| 166 kg K/ha | 1 | 11.84 | 10 000 | 118 400 | 63 000 | 55 400 | 0.9 |
| 166 kg K/ha | 2 | 14.93 | 10 000 | 149 300 | 73 000 | 76 300 | 1.0 |
| 166 kg K/ha | 3 | 17.76 | 10 000 | 177 600 | 83 000 | 94 600 | 1.1 |
| 166 kg K/ha | 4 | 12.50 | 10 000 | 125 000 | 69 250 | 55 750 | 0.8 |
| 166 kg K/ha | 5 | 18.10 | 10 000 | 181 000 | 79 250 | 101 750 | 1.3 |
| 166 kg K/ha | 6 | 20.62 | 10 000 | 206 200 | 89 250 | 116 950 | 1.3 |
| 166 kg K/ha | 7 | 20.04 | 10 000 | 200 400 | 75 500 | 124 900 | 1.7 |
| 166 kg K/ha | 8 | 23.08 | 10 000 | 230 800 | 85 500 | 145 300 | 1.7 |
| 166 kg K/ha | 9 | 20.04 | 10 000 | 200 400 | 95 500 | 104 900 | 1.1 |

* CBR (greater than 2) underlined are the most economical
1 = Control, 2 = 10 MT FYM/ha, 3 = 20 MT FYM/ha, 4 = 50 kg P/ha, 5 = 50 kg P/ha, 6 = 50 kg P/ha + 20 MT FYM/ha, 7 = 100 kg P/ha, 8 = 100 kg P/ha + 10 MT FYM/ha, 9 = 100 kg P/ha + 20 MT FYM/ha

**Tab. 4:** Chemical composition of applied farm yard manure

| pH | Na me% | K me% | Ca me% | Mg me% | Mn me% | P ppm | N % | C % |
|---|---|---|---|---|---|---|---|---|
| 8.5 | 0.5 | 15.0 | 52.9 | 8.3 | 0.2 | 171 | 43 | 4.3 |

*Received for publication on February 26, 2008*
*Accepted for publication on June 17, 2009*

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