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# Effect of different proportion of organic and inorganic nutrients on productivity and profitability of potato (*Solanum tuberosum*) varieties in Meghalaya hills

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## ABSTRACT

A field experiment was conducted during summer seasons of 2005 and 2006 at Shillong in split plot design having three potato varieties in the main plots and six organic-inorganic nutrient combinations in the sub-plots with four replications. Among the varieties, *Kufri Megha* recorded significantly higher tuber yield when compared with *Kufri Giriraj* and *Kufri Jyoti*. Number of tubers/plant, mean tuber weight, marketable and total tuber yield of potato increased significantly due to the use of recommended dose of fertilizers (RDF) i.e. 120-52.4-50 kg N-P-K/ha or 75% RDF + 25% recommended dose of N (RDN) through FYM. The yield components and tuber yield decreased gradually as the crop received higher proportion of plant nutrients through FYM. Accordingly, substitution of RDN by FYM resulted in lower tuber productivity which was significantly lower than those of other organic-inorganic combinations except control. *Kufri Megha* receiving RDF or 75% RDF + 25% RDN through FYM produced the highest tuber yield (27.11/26.98 t/ha) among all treatment combinations. High net return was obtained from the crop receiving 100% RDF or 25% RDN through FYM + 75% RDF. *Kufri Megha* at RDF or 75% RDF + 25% RDN through FYM may be recommended for better growth, higher tuber yield and greater net return from potato cultivation in the North Eastern Hill Region of Meghalaya.

***Key words***: Nutrient management, Organic, Potato, Productivity, Profitability

The green revolution technology involving indiscriminate use of fertilizers and pesticides with adoption of nutrient responsive high yielding crop varieties have boosted the productivity. Of late, concern has been raised over its adverse affect on soil erosion, depletion of organic matter in soil, low availability of water, contamination of food and water due to agrochemicals and also adverse affect on biodiversity. Organic farming is one of the options to restore the productivity of degraded soils (Ghosh *et al.,* 2007). Gaur (2001) and Govindakrishnan and Kushwah (2003) reported that organic farming is the need of the day that avoids depletion of soil organic matter and plant nutrients. Kumar *et al.* (2005) and Manna *et al*. (2006) recorded prolonged effect of organic manures on soil fertility and soil moisture balance. It also reduces the chemicals needed for pest control, besides improving soil physical properties in long run. But organic farming alone may not meet the requirements of agricultural productivity and solve food and other problems. Proportionate combination of organic and inorganic sources of plant nutrients has been found to be the best option for increasing productivity and maintaining sustainability in crop production. As no single source is capable of supplying the required amount of plant nutrients, integrated use of all sources of plant nutrients is a must to supply balanced nutrition to the crops (Arora, 2008). There is need to develop and demonstrate balanced use of organic manures and chemical fertilizers not only to increase crop productivity but also to recycle the precious national resources and minimize the environmental damage. Good quality seed is another factor in regulating crop productivity. Roy Burman *et al.* (2007) after elaborate studies at Central Potato Research Station in Shillong observed that *Kufri Jyoti, Kufri Megha* and *Kufri Giriraj* were suitable for cultivation in the North Eastern Hill Region. Practically no work has been done on judicious use of organic manures and chemical fertilizers for improving the productivity and profitability of the above potato varieties in this region. The present study was made to find out profitable combination of organic manures and chemical fertilizers required for these varieties in Meghalaya hills.

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## MATERIALS AND METHODS

A field experiment was conducted during summer sea-

son of 2005 and 2006 at Central Potato Research Station, Shillong (26°2' N latitude and 89°4' E longitude and at an elevation of 900 m above mean sea level). The soil was sandy loam in texture, acidic in reaction (pH 5.4) medium in organic carbon (0.69%), low in nitrogen (163 kg/ha) and phosphorous (13 kg/ha) and high in potassium (390 kg/ha) status. The experimental site comes under humid region where monsoon normally starts by the middle of April and extends up to September. Pre-monsoon showers during middle of March (unpredictable) are of great advantage particularly for growing of summer potato. The annual rainfall in this area is 2,644 mm and nearly 70% of rainfall is received through North-East monsoons during April to September. The maximum and minimum temperatures during crop growing season varied from 20.1 to 25.7$^0$C and 9.8 to 19.0 $^0$C and are very conducive for potato tuber productivity. The experiment was laid out in split plot design with four replications on a fixed plot. The main plot treatments consisted of three potato varieties (*Kufri Jyoti, Kufri Giriraj* and *Kufri Megha*) and sub-plot treatments of six organic-inorganic nutrient combinations ($N_1$, 25% recommended dose of N (RDN) through FYM +75% recommended dose of NPK fertilizers (RDF), $N_2$, 50% RDN through FYM +50% RDF, $N_3$, 75% RDN through FYM +25% RDF, $N_4$, RDN through FYM (containing 0.50% N, 0.089% P and 0.417% K), $N_5$, RDF (120-52.4-50 kg N-P-K/ha) and $N_6$, Control). The crop was planted in the middle of March during both the years at a spacing of 60 cm x 20 cm. Observations on growth attributes at different stages, yield components and crop productivity were recorded at harvest. Nutrient uptake as per standard procedures and economics of potato production considering the local market price of inputs and out puts were also estimated.

## RESULTS AND DISCUSSION

### *Crop growth*

The results showed that potato variety *Kufri Megha* and *Kufri Giriraj* produced significantly taller plants and greater number of branches/plant than those of *Kufri Jyoti* during both the years. Similarly both *Kufri Megha* and *Kufri Giriraj* recorded higher dry matter accumulation (DMA) and greater dry matter partitioning into tubers which was significantly superior to *Kufri Jyoti* during both the years (Table 1). The varietal differences in plant height, branch production, dry matter accumulation and partitioning might be due to genetic composition of the variety (Singh, 2005). The leaf area index (LAI) did not vary significantly among the potato varieties at all the growth stages during both the years under study except at 90 DAP in 2006 where both *Kufri Megha* and *Kufri Giriraj* recorded significantly higher values of LAI than that of *Kufri Jyoti* (Table 1). This might be due to late growth habit of *Kufri Giriraj* and *Kufri Megha* in comparison to *Kufri Jyoti* ( Mondal and Sarkar, 2005).

The nutrient management system showed a positive response on influencing the height and branching of the potato plants. Application RDF or 75% RDF + 25% RDN through FYM produced taller plants and higher number of branches/plant as compared to other nutrient management treatments during both the years (Table 1). The crop of the control plot (receiving no fertilizers or manure) produced the least values of above two parameters. Dry matter accumulation and partitioning varied significantly due to different nutrient management practices. The highest DMA was recorded in crop receiving RDF which was closely followed by 75% RDF + 25% RDN through FYM and significantly greater than those recorded in all other fertility treatments during both the years (Table 1). But the highest dry matter partitioning into tubers was obtained from the crop receiving RDN through FYM, which was significantly greater than those recorded in the above two nutrient management treatments during both the years. This might be due to balanced nutrition through organic manures. This is in conformity with the findings of Upadhyaya *et al*. (2003). The LAI recorded from the crop receiving RDF being at par with crop receiving 75% RDF + 25% RDN through FYM was significantly greater than those of the crop grown at other treatments at all the growth stages during both the years (Table 1). The high values of LAI throughout the growth period were also noticed by Kumar *et al.* (2005) due to high level of balanced nutrient application. The crop in the control plot produced the lowest LAI values. The results indicate that high dose of balanced fertilizer is essential for increasing the LAI and growth of potato crop.

### *Yield attributes and yield*

The results showed remarkable variation in number of tubers/plant, mean tuber weight and tuber yield among the potato varieties and nutrient management treatments (Table 2). Significantly greater tubers/plant were recorded in *Kufri Jyoti* than those of *Kufri Giriraj* and *Kufri Megha* during both the years. Number of tubers/plant did not differ much between *Kufri Giriraj* and *Kufri Megha* during both the years. But, *Kufri Megha* recorded significantly higher mean weight of tuber than *Kufri Jyoti* and *Kufri Giriraj* during both the years. *Kufri Giriraj* also recorded higher mean weight of tuber than those of *Kufri Jyoti*. This might be due to the inherent capacity of the variety to contribute differently in tuber productivity (Singh, 2005).

The marketable and total tuber yield was significantly higher in *Kufri Megha* than other varieties during both the years. However, during 2005, marketable tuber yield of

*Kufri Megha* and *Kufri Giriraj* was similar. High tuber yield of *Kufri Megha* was mainly due to high tuber bulking resulting in greater tuber weight in comparison to other varieties. Similar trend of results was also obtained by Kumar *et al.* (2005) and Roy Burman *et al.* (2007).

The crop receiving RDF closely followed by 75% RDF + 25% RDN through FYM during both the years produced significantly higher number of tubers/plant, tuber weight as compared to other nutrient management treatments during both the years. The number of tubers/plant decreased steadily as the crop received higher proportion of N through FYM. Accordingly, substitution of RDN by FYM resulted in the production of least number of tubers/plant, which was significantly lower than those of other nutrient treatments except control during both the years. Slow rate of mineralization of organic matter at low temperature prevailing in potato growing season in the North Eastern Hill region might affect the nutrient supply and thus decreased the tuber formation and tuber bulking as reflected by lower number of tubers/plant in plots having high rate of nutrient supply through FYM. The results are in conformity with the findings of Kumar *et al.* (2005).

**Table 1.** Effect of variety and organic-inorganic nutrient management on growth attributes of potato (90 DAP) and leaf area index (60 and 90 DAS)

| Treatment | Plant height (cm) | | No. of branches/ plant | | Dry matter accumulation ($g/m^2$) | | Dry matter partitioning into tubers (%) | | LAI | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 60 DAP | | 90 DAP | |
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| *Variety* | | | | | | | | | | | | |
| Kufri Jyoti | 32.9 | 36.9 | 5.1 | 5.2 | 868 | 899 | 50.5 | 51.8 | 3.12 | 3.25 | 3.04 | 2.71 |
| Kufri Giriraj | 34.2 | 38.3 | 5.4 | 5.6 | 946 | 969 | 53.4 | 54.5 | 3.11 | 3.20 | 3.00 | 2.96 |
| Kufri Megha | 35.8 | 41.1 | 5.6 | 5.7 | 940 | 978 | 54.4 | 55.1 | 3.11 | 3.30 | 3.04 | 3.07 |
| SEm± | 0.3 | 0.4 | 0.1 | 0.1 | 9 | 9 | 0.5 | 0.7 | 0.04 | 0.06 | 0.05 | 0.07 |
| CD (P=0.05) | 1.1 | 1.2 | 0.2 | 0.2 | 28 | 31 | 1.7 | 2.3 | NS | NS | NS | 0.23 |
| *Nutrient management (% inorganic + % FYM N)* | | | | | | | | | | | | |
| 75 + 25 | 38.2 | 44.9 | 6.1 | 6.3 | 1,073 | 1,138 | 52.0 | 53.0 | 3.38 | 3.44 | 3.26 | 3.21 |
| 50 + 50 | 37.3 | 42.4 | 5.9 | 5.9 | 1,019 | 1,033 | 53.2 | 54.1 | 3.23 | 3.34 | 3.18 | 3.07 |
| 25 + 75 | 34.2 | 39.6 | 5.0 | 5.5 | 879 | 957 | 53.6 | 55.6 | 3.02 | 3.16 | 3.02 | 2.94 |
| 0 + 100 | 31.2 | 34.1 | 4.6 | 5.0 | 823 | 817 | 54.8 | 56.0 | 2.91 | 3.00 | 2.99 | 2.82 |
| 100 + 0 | 38.3 | 45.5 | 6.3 | 6.4 | 1,096 | 1,159 | 51.2 | 51.7 | 3.44 | 3.63 | 3.30 | 3.06 |
| Control | 26.7 | 26.2 | 4.2 | 3.8 | 620 | 588 | 52.6 | 53.2 | 2.67 | 2.90 | 2.50 | 2.47 |
| SEm± | 0.3 | 0.4 | 0.1 | 0.1 | 10 | 11 | 0.7 | 0.8 | 0.05 | 0.07 | 0.06 | 0.06 |
| CD (P=0.05) | 0.9 | 1.0 | 0.2 | 0.2 | 28 | 30 | 1.9 | 2.1 | 0.14 | 0.21 | 0.17 | 0.17 |

*DAP, Days after planting

**Table 2.** Effect of variety and organic-inorganic nutrient management on yield components and tuber yield (t/ha) of potato

| Treatment | Tubers/plant | | Tuber weight (g/tuber) | | Marketable tuber yield | | Total tuber yield | |
|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| *Variety* | | | | | | | | |
| Kufri Jyoti | 7.36 | 7.53 | 37.0 | 37.6 | 16.70 | 16.92 | 20.44 | 21.11 |
| Kufri Giriraj | 7.11 | 7.01 | 39.0 | 42.3 | 17.24 | 18.78 | 21.21 | 22.29 |
| Kufri Megha | 7.09 | 6.82 | 40.5 | 48.2 | 17.43 | 20.00 | 21.88 | 24.16 |
| SEm± | 0.05 | 0.08 | 0.5 | 0.6 | 0.14 | 0.18 | 0.19 | 0.25 |
| CD (P=0.05) | 0.17 | 0.25 | 1.4 | 2.2 | 0.48 | 0.58 | 0.66 | 0.89 |
| *Nutrient management (% inorganic + % FYM N)* | | | | | | | | |
| 25 + 75 | 8.25 | 8.30 | 40.6 | 43.7 | 20.03 | 21.57 | 24.25 | 26.59 |
| 50 + 50 | 7.91 | 7.88 | 39.0 | 42.1 | 18.85 | 19.92 | 22.35 | 24.96 |
| 75 + 25 | 7.48 | 7.33 | 38.9 | 41.7 | 17.10 | 18.79 | 21.15 | 23.70 |
| 0 + 100 | 6.27 | 6.02 | 38.5 | 41.4 | 14.24 | 17.22 | 19.27 | 21.84 |
| 100 + 0 | 8.28 | 8.37 | 40.8 | 43.9 | 20.22 | 22.03 | 25.00 | 27.30 |
| Control | 4.79 | 5.05 | 38.0 | 41.1 | 12.29 | 14.50 | 15.57 | 16.57 |
| SEm± | 0.07 | 0.06 | 0.5 | 0.6 | 0.24 | 0.28 | 0.29 | 0.33 |
| CD (P=0.05) | 0.20 | 0.17 | 1.5 | 1.6 | 0.68 | 0.81 | 0.86 | 0.95 |

Marketable and total tuber yield followed a trend similar to that of number and weight of tubers/plant. The crop receiving RDF or 75% RDF + 25% RDN through FYM produced the high yield of both marketable and total tubers which was significantly greater than those of the other treatments during both the years (Table 2). Both marketable and total tuber yields decreased steadily and significantly as amount N supply through FYM increased from 25% to 100%. The crop of the control plots produced the lowest amount of marketable as well as total tuber yield. The results indicated that the crop required 75% RDF + 25% RDN through FYM for its better growth and higher tuber yield under North Eastern Hill Region. High rate of tuber formation and tuber bulking of the crop under adequate nutrient supply either through chemical fertilizers or 75% NPK through chemical fertilizers and remaining 25% N through FYM was mainly responsible for increasing the number tubers/plant and tuber weight that ultimately resulted in high potato tuber yield. The results corroborate the findings of Mondal and Sarkar (2005).

Significant interaction effect of variety and nutrient management was observed (Table 3). Kufri Megha receiving RDF (27.11 t/ha) or 75% RDF + 25% RDN through FYM (26.98 t/ha) produced significantly higher tuber yield than other combinations. This was because Kufri Megha showed faster tuber bulking capacity than other varieties at better nutrient management. The lowest tuber yield was noted in Kufri Jyoti when grown without fertilizers (14.94 t/ha). Similar varietal response to nutrient management has also been reported by Kumar *et al.* (2009).

### *Nutrient uptake and use efficiency*

Kufri Megha recorded significantly higher N, P and K uptake than Kufri Giriraj and Kufri Jyoti (Table 4). Kufri Giriraj also showed its superiority over Kufri Jyoti in re-

**Table 3.** Interaction effect of variety and organic-inorganic nutrient management on tuber yield (t/ha) of potato (pooled data of 2 years)

| Nutrient Management (B) (% inorganic + % FYM N) | Variety (A) | | |
|---|---|---|---|
| | Kufri Jyoti | Kufri Giriraj | Kufri Megha |
| 75 + 25 | 23.92 | 24.77 | 26.98 |
| 50 + 50 | 21.92 | 22.90 | 24.59 |
| 25 + 75 | 20.83 | 21.94 | 22.87 |
| 0 + 100 | 19.35 | 19.35 | 20.67 |
| 100 + 0 | 24.02 | 25.34 | 27.11 |
| Control | 14.94 | 16.69 | 16.97 |
| | B at same A | A at same B | |
| SEm± | 0.33 | 0.40 | |
| CD (P=0.05) | 1.11 | 1.27 | |

**Table 4.** Effect of variety and organic-inorganic nutrient management on nutrient uptake and nutrient use efficiency and economics of potato

| Treatment | N uptake (kg/ha) | | P uptake (kg/ha) | | K uptake (kg/ha) | | Nutrient use efficiency (kg/kg) | | Cost of cultivation (Rs/ha) | | Net return (Rs/ha) | | Return/rupee invested | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| *Variety* | | | | | | | | | | | | | | |
| Kufri Jyoti | 168.9 | 182.1 | 13.35 | 13.95 | 174.1 | 187.6 | 13.67 | 11.83 | 35,965 | 36,401 | 66,235 | 69,149 | 1.84 | 1.90 |
| Kufri Giriraj | 174.4 | 186.2 | 13.81 | 14.73 | 180.5 | 192.7 | 15.30 | 14.53 | 36,446 | 37,138 | 69,604 | 74,312 | 1.91 | 2.00 |
| Kufri Megha | 178.3 | 190.6 | 14.20 | 15.17 | 185.0 | 197.8 | 16.71 | 18.81 | 36,865 | 38,307 | 72,535 | 82,493 | 1.97 | 2.15 |
| SEm± | 1.2 | 1.2 | 0.11 | 0.12 | 1.5 | 1.6 | 0.42 | 0.61 | | | 875 | 932 | 0.04 | 0.06 |
| CD (P=0.05) | 3.7 | 4.0 | 0.38 | 0.40 | 4.5 | 5.0 | 1.35 | 1.93 | | | 2,695 | 2,852 | 0.12 | 0.18 |
| *Nutrient management (% inorganic + % FYM N)* | | | | | | | | | | | | | | |
| 25 + 75 | 217.8 | 230.1 | 17.26 | 17.97 | 224.9 | 236.8 | 18.87 | 20.67 | 40,732 | 41,965 | 80,518 | 90,985 | 1.98 | 2.17 |
| 50 + 50 | 191.4 | 201.0 | 15.15 | 15.51 | 194.9 | 204.2 | 16.89 | 19.94 | 38,756 | 40,275 | 72,994 | 84,525 | 1.88 | 2.10 |
| 75 + 25 | 169.0 | 181.2 | 13.16 | 13.77 | 179.2 | 189.4 | 15.44 | 18.55 | 37,055 | 39,330 | 68,695 | 84,171 | 1.85 | 2.14 |
| 0 + 100 | 136.1 | 147.6 | 10.93 | 11.58 | 141.6 | 156.1 | 12.82 | 16.72 | 35,071 | 37,137 | 61,279 | 72,063 | 1.75 | 1.94 |
| 100 + 0 | 220.9 | 233.1 | 17.41 | 18.50 | 226.6 | 240.7 | 20.32 | 21.80 | 41,540 | 42,904 | 83,460 | 93,597 | 2.01 | 2.18 |
| Control | 108.9 | 122.9 | 8.8 | 9.96 | 110.2 | 127.8 | | | 26,131 | 26,356 | 51,119 | 55,494 | 1.96 | 2.11 |
| SEm± | 1.6 | 1.7 | 0.21 | 0.26 | 1.7 | 1.8 | 0.68 | 0.71 | | | 752 | 875 | 0.06 | 0.05 |
| CD (P=0.05) | 4.9 | 5.2 | 0.62 | 0.77 | 5.0 | 5.2 | 1.99 | 2.05 | | | 2,211 | 2,573 | 0.17 | 0.14 |

*Economics based on cost of Urea, Rs 5.04/kg; SSP, Rs 8.23/kg; MOP, Rs. 5/kg; Organic manure, Rs 275/tonne; labour, Rs 60/man-day; Price of potato, Rs 5/kg

spect of nutrient uptake. Kufri Jyoti recorded the lowest uptake of N, P and K and its lowest use efficiency because of its low productivity in comparison to those of Kufri Megha and Kufri Giriraj in the North Eastern Hill region.

The nutrient management system showed significant effect on nutrient uptake and nutrient use efficiency by crop. Crop receiving RDF closely followed by the crop having 75% RDF + 25% RDN through FYM during both the years (Table 4) recorded significantly higher nutrient uptake and nutrient use efficiency. They decreased steadily and gradually due to the increase in use of FYM and the crop receiving RDN through FYM recorded low nutrient uptake and use efficiency than control. Slow mineralization of organic manure at low temperature condition in potato growing season in the North Eastern Hill region might have affected the nutrient supply and thus decreased the nutrient uptake by the crop. The crop receiving RDN through FYM registered the lowest nutrient use efficiency. The results showed that 25% substitution of N through FYM and 75% RDF was appropriate for producing higher tuber yield with greater nutrient use efficiency comparable to that of the crop at RDF. The results corroborate the findings of Mondal and Sarkar (2005).

### *Economics*

The results showed that net return (Rs/ha) Benefit: cost ratio was markedly higher in Kufri Megha and with RDF or 75% RDF + 25% RDN through FYM (Table 4). The net return decreased gradually as the crop received higher proportion of N through FYM. Accordingly, the crop receiving N through FYM recorded the lower net return than other treatments except control during both the years. Benefit: cost ratio did not vary much among the fertility treatments except the application of RDN through FYM has lowest value. The control plots recorded quite high B:C ratio because of no cost of chemical fertilizers. The results are in conformity with the findings of Mondal and Sarkar (2005).

Consequently application of (120-52.4-50 kg N-P-K/ha i.e. RDF) or 75% RDF + 25% RDN through FYM registered higher tuber yield than other nutrient management treatments. Kufri Megha receiving RDF or 75% RDF + 25% RDN through FYM performed best among all other treatment combinations may be recommended for potato cultivation to obtain good growth, high tuber yield and net return in the North-Eastern Hills region of Meghalaya.

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