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Effect of integrated nitrogen management on yield of potato (*Solanum tuberosum* L.): Local cultivar, *Alu Amubi*

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Abstract
A field experiment was conducted during the *rabi* season of 2017-18 to study the effect of integrated nitrogen management on yield of potato (*Solanum tuberosum* L.) – Local cultivar, *Alu Amubi*" at Central Agricultural University, Imphal. There were seven treatments *viz*. control, 100% RDN through urea, 75% RDN through urea + 25% through FYM, 75% RDN through urea + 25% through VC, 50% RDN through urea + 50% through FYM, 50% RDN through urea + 50% through VC and 50% RDN through FYM + 50% RDN through VC laid out in a randomized block design with three replications. Integration of 75% RDN through urea + 25% through FYM increased growth and yield parameters and tuber yield. However, it remained at par with application of 75% RDN through urea + 25% through VC. Highest net returns and benefit cost ratio were also associated with application of 75% RDN through urea + 25% through FYM.

Keywords: Integrated nitrogen management, potato, FYM, VC, tuber yield, net returns.

Introduction
Potato being a short duration crop having sparse root system is highly responsive to applied nutrients. Being a heavy feeder crop, it requires adequate supply of plant nutrients for proper growth, high tuber yield and remunerative production. Ever since the beginning of the Green Revolution the nutrient requirement of potato is mainly met through chemical fertilizers. Overtime, the intensive use of inorganic fertilizers and other agrochemicals has led to considerable depletion of soil organic matter, contamination of water and food and also adverse effect on biodiversity (Baishya *et al.*, 2010 [1]; Gunjal and Chitodkar, 2017 [2]). In addition to its adverse effects, the ever increasing cost of chemical fertilizers has led to under application of recommended nutrients by farmers resulting in lower yields. In contrast, besides supplying plant nutrients and improving soil structure, organic manures also improve the physical, chemical and biological properties of the soil. However, being slow nutrient releasing fertilizers, organic sources alone cannot produce yields that will feed the ever increasing human population globally.

For increased production, sustainable productivity and tuber quality, a comprehensive nutrient management program with minimal negative effects on the environment, at the same time giving optimum yield, is necessary for managing a remunerative health potato crop. The conjunctive use of synthetic fertilizer along with organic sources of nutrients minimizes the depletion of soil organic matter and the gap between potential yield and actual yield is bridged to a greater extent (Tolanur and Badanur, 2003) [3]. Therefore, adoption of integrated nutrient management will not only improve crop yields but also restore the soil health and minimize on the adverse effects that come along with continuous application of chemical fertilizers alone.

Materials and Methods
The experiment was conducted during the *rabi* season of 2017-18 at the research farm of the College of Agriculture, Central Agricultural University, Imphal. The site is located at 24^0 45' N latitude and 93^0 54' E longitudes and an altitude of 774.5 meters above sea level. The experiment was laid in a Randomized Block Design with seven treatments and three replications. The treatments were; T_1 (Control with no N applied), T_2 (100% RDN through urea), T_3 (75% RDN through urea + 25% through FYM), T_4 (75% RDN through urea + 25% through VC), T_5 (50% RDN through urea + 50% through FYM), T_6 (50% RDN through urea +

50% through VC) and T_7 (50% RDN through FYM + 50% through VC). The soil of the experimental site was clay in texture with a pH of 5.27, 0.8% organic carbon, 262.72 kg/ha available nitrogen, 19.45 kg/ha available phosphorus, 264.08 kg/ha available potassium.

The experimental field was ploughed twice by a tractor followed by power tiller to break the clods and bring the field to the desired tilth. Levelling was done manually followed by sub-dividing the field into individual plots as per layout.

Full doses of P_2O_5 and K_2O in form of SSP and MOP respectively were applied uniformly at the rate of 100 kg/ha before planting. Farmyard manure and vermicompost were applied 10 days before planting. Fifty per cent of urea was applied just before planting. The FYM, VC and urea were applied as per treatment as basal dressing fertilizer. The remaining fifty percent of urea was applied as top dressing fertilizer at 25 days after planting. The application rates were 100 kg/ha, 16 t/ha and 2 t/ha for N (through urea), FYM and VC respectively. Sprouted tubers (12.2 g weight and 4.6 cm shoot length) were planted 50 cm x 20 cm apart and 6 cm deep. Weeding and earthing up was done at 25 days after planting with the help of a spade. The crop was irrigated 8 times depending on the moisture status of the soil. From 45 days after planting (DAP) the soil was kept moist throughout the growing season to ensure proper growth and development of the crop.

Growth attributes of potato were recorded during the maximum vegetative growth stage while the yield attributes were recorded at harvest. The significance of different sources of variations were tested by Standard Error of Deviation by Fisher and Snedecor's 'F' test at probability level, P=0.05.

Results and Discussion

Growth parameters

Integrated nitrogen management significantly influenced the growth of potato (Table 1). Application of 75% RDN through urea in combination with 25% through FYM (T_3) significantly increased plant height (33.63 cm), number of branches (13.27)/plant, number of leaves (46.33)/plant and leaf area index (2.69) which remained statistically at par with the application of 75% RDN through urea integrated with 25% of vermicompost (T_4). All the treatments with integrated sources of nutrients performed better than the control. This might be due to increase in nitrogen content as a result of mineralization of the FYM and vermicompost which led to sufficient supply of nutrients and balanced nutrition throughout the growing period thus favouring fast growth of the plants. Application of 100% RDN through urea did not perform well which might be due to leaching losses. Use of organic sources at 100% (T_7 50% FYM + 50% VC) recorded much less values which might be due to slow rate of mineralization of the organic sources due to lower temperature in the early stages of plant growth. These results are in line with the findings of Baishya *et al.* (2010) [1], Yadav *et al.* (2014) [4], Najm *et al.* (2010) [5] and Mama *et al.* (2016) [6] who also reported the significant effect of integrated nutrient management practices on growth of potato.

Yield parameters and tuber yield

Integrated nitrogen management had significant influence on the number of different grades of potato tubers, weight of tubers per plant, tuber yield and harvest index (Table 2). Highest number of total tubers per plant as well as small, medium and large grades of tubers was associated with the application of 75% RDN through urea + 25% through FYM (T_3) over the control. Similarly, higher values of weight of tubers per plant, tuber yield and harvest index were observed under the same treatment. However, there was no significant difference with the application of 75% RDN through urea + 25% through VC (T_4) except for harvest index. Lowest values were recorded under the control. The higher values of the above mentioned yield parameters and tuber yield associated with the combined use of organic and inorganic fertilizer might be attributed to improved soil physical, chemical and biological properties due to the presence of organic manure, which consequently retained moisture for longer period for a water-loving crop like potato. Besides improving water holding capacity of the soil, organic sources are known for supplying macro and micronutrients slowly to the crop. Further, the nutrient supply might have been regulated by the presence of manure in such a way that the supply during the initial stages of growth was in adequate amounts and readily available ionic forms thus increasing the photosynthetic activity. At later stages of growth, through mineralization, the FYM and VC continuously supplied balanced nutrition to the crop consequently initiating more stolons per plant, increasing the rate of tuber formation, efficient direction of assimilates to the tubers, increasing the number of tubers per plant and tuber weight which ultimately resulted in high potato tuber yield. Similar findings were reported by Keisham *et al.* (2015) [7], Ahmed *et al.* (2017), [8] Yadav *et al*. (2017) [4] Ferdoushi *et al.* (2010) [9], Narayan *et al*. (2014) [10] and Baishya *et al.* (2010) [1]. Sole application of 100% RDN (T_2) through urea did not record higher values as compared to when 25% or 50% RDN was replaced by either FYM or VC which might be due to leaching losses.

Further, integrated use of FYM and urea at different levels performed better than when urea was integrated with VC even though they remained in parity. This might be partly attributed to the fact that the quantity of FYM was higher than that of VC which consequently improved the soil physical status to a greater extent ultimately improving soil water dynamics which supported better growth and yield of potato. Gunjal and Chitodkar (2017) [2] observed that application of FYM in combination with inorganic fertilizer increased hydraulic conductivity and reduced the permanent wilting point than VC. Keisham *et al*. (2015) [7] also reported the superiority of FYM over VC when integrated with inorganic fertilizers.

Economics

Knowing the fact that farming is a business, the economic feasibility of any practice to be adopted cannot be overemphasized. The current study reviewed that all the treatments gave higher gross and net income and benefit cost ratio over the control (Table 3). The highest cost of cultivation was associated with application of 100% RDN through organic sources (T_7, 50% FYM +50% VC) which might be due to large amounts of organic sources of nutrients. On the other hand, the highest gross and net income and benefit cost ratio were associated with application of 75% RDN through urea + 25% through FYM followed by the treatment that received 75% RDN through urea + 25% through VC. Integration of urea and FYM at any level gave higher benefit cost ratio as compared to integration of urea and VC. This might be attributed to the high cost (`15/kg) per unit of VC as compared to FYM (`2/kg). However, the lowest cost of cultivation was obtained under the control to which no nitrogen was applied and lowest net income and B: C ratio was associated with the same treatment. The results prove that

for remunerative potato production, integrated nitrogen management is necessary. Higher income and B: C ratio associated with the integration of inorganic fertilizers and FYM were also reported by Baishya *et al.* (2010) [1], Yadav *et al*. (2017) [11] and Boke (2014) [12].

Conclusion

An overview of the results obtained from the present study suggests that integration of different sources of nitrogen in appropriate proportions can enhance the production and productivity of potato in Manipur as compared to sole application of 100% recommended dose of nutrients through either organic or inorganic sources. Integration of 75% RDN through urea + 25% through FYM did not only significantly influence the growth and yield parameters but also recorded the highest yield and proved to be economically feasible. Therefore, for remunerative and sustainable production and productivity of potato, farmers in Imphal may adopt the combination of 75% RDN through urea + 25% through FYM.

Table 1: Effect of integrated nitrogen management on growth parameters

Treatment	Plant height (cm)	No. of branches /plant	No. of leaves/plant	LAI
T_1 Control (No N applied)	18.76	7.77	23.00	1.13
T_2 100% RDN	25.00	10.24	35.40	2.07
T_3 75% RDN + 25% FYM	33.63	13.27	46.33	2.69
T_4 75% RDN + 25% VC	30.86	12.80	45.80	2.42
T_5 50% RDN + 50% FYM	26.56	10.74	38.40	2.37
T_6 50% RDN + 50% VC	25.88	10.42	35.73	2.26
T_7 50% FYM + 50% VC	22.33	9.57	32.00	2.03
SE d(±)	1.29	0.37	2.16	0.27
CD (P=0.05)	2.81	0.80	4.71	0.59

RDN = recommended dose of nitrogen through urea; FYM = Farmyard manure; VC= Vermicompost

Table 2: Effect of integrated nitrogen management on yield parameters and tuber yield

Treatment	No. of tubers/plant			Total No. of tubers /plant	Tuber weight /plant (g)	Tuber yield (q/ha)	Harvest index (%)
	Small (<20g)	Medium (20-35g)	Large (>35g)				
T_1 Control (No N applied)	8.06	2.37	1.3	11.73	95.67	29.99	68.18
T_2 100% RDN	11.6	3.47	1.93	17.02	122.07	59.13	71.14
T_3 75% RDN + 25% FYM	15.6	4.17	3.07	22.83	205.33	83.87	75.28
T_4 75% RDN + 25% VC	14.43	4.07	3.03	21.53	190.07	78.29	72.16
T_5 50% RDN + 50% FYM	12.46	3.53	2.2	18.19	145.53	64	71.4
T_6 50% RDN + 50% VC	12.33	3.52	2.13	17.98	145	60.46	71.26
T_7 50% FYM + 50% VC	11.06	3.04	1.73	15.83	110.07	52.99	71.08
SE d(±)	1.25	0.2	0.18	0.85	11.76	5.4	1.05
CD P=0.05)	2.72	0.43	0.39	1.85	25.63	11.77	2.29

Table 3: Economics of potato cultivation as influenced by of integrated nitrogen management

Treatment	Yield (q/ha)	Rate (`/kg)	Gross income (`/ha)	Cost of cultivation (`/ha)	Net income (`/ha)	B:C
T_1 Control (No N applied)	29.99	50	149966.67	125175.00	24791.67	0.20
T_2 100% RDN	59.13	50	295633.33	126175.00	169458.33	1.34
T_3 75% RDN + 25% FYM	83.87	50	419333.33	133925.00	285408.33	2.13
T_4 75% RDN + 25% VC	78.29	50	391466.67	133425.00	258041.67	1.93
T_5 50% RDN + 50% FYM	64.00	50	320016.67	141675.00	178341.67	1.26
T_6 50% RDN + 50% VC	60.46	50	302300.00	140675.00	161625.00	1.15
T_7 50% FYM + 50% VC	52.99	50	264966.67	156175.00	108791.67	0.70

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