

Effect of Seed Rate and Integrated Nutrient Management on Potato Yield and Economics under Rainfed Conditions in NEH Region

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Abstract

A field experiment was conducted during summer season (March-July) of 2008 and 2009 at upper Shillong (Meghalaya) on a sandy loam acidic soil under rainfed condition in split plot design with three seed rates and five fertility levels to study its effect on yield and economics of potato production with the view to evolve low cost input technology for potato production. Plant height, number of stems/ha, haulm weight at harvest, LAI, and uptake of N, P and K increased significantly with increase in seed rate. Significantly higher yield and number of medium and small size tuber and total tuber was recorded with increasing seed rate. Large tuber yield and number increased with increase in seed rate up to 20 q/ha. Average tuber weight decreased with increase in seed rate from 15 to 25 q/ha. The benefit : cost ratio was highest (1.55) with seed rate of 20 q/ha while it was only 1.51 at seed rate of 25 q/ha. There was significant increase in yield and number of large and medium size tuber due to improved fertility. The highest yield of large and medium size tuber and total tuber, uptake of N, P and K, gross return, net return and B : C ratio was recorded with application of FYM at 25 t/ha + recommended dose of fertilizer (RDF). Application of FYM at 25t/ha + ½ RDF produced large and medium grade tuber yield as well as total tuber yield, net return and B : C ratio at par to sole RDF. The average tuber weight decreased with decreasing fertility levels.

Key words : Integrated nutrient management, Potato, Seed rate.

Potato is a major crop of Meghalaya with an area and production of 18,200 ha and 147,000 tones, respectively (1). The area under potato cultivation is 8.6% of the total cropped area in the state. Majority of farmers in Meghalaya are small and marginal with limited resources. Besides, low and uncertain yield due to rainfed condition and occurrence of late blight disease in epidemic form necessitate the urgency to reduce the cost of cultivation. Potato is an input intensive crop. The seed tuber alone accounts for 50% of total cost of cultivation while manures and fertilizers accounts for further 12—15% (2). Reducing the cost of seed by planting cut seed tuber is not recommended because of occurrence of heavy incidence of bacterial wilt inoculums in the soils of Meghalaya. The use of small size (20-25g) tubers as planting material can reduce the seed rate and seed cost significantly (3). Nutrition management plays a significant role in potato yield. Yield attributing characters of potato i.e. number and sizes of tubers are governed by several factors out of which spacing and fertiliza-

tion rate are important. Hence an investigation was undertaken to evaluate the effect of fertilizer management and seed rate for optimizing yield with minimum cost of cultivation under prevailing agro climates conditions of Meghalaya.

Methods

The experiment was conducted during the summer season (March-July) at Central Potato Research Station, Shillong (1,790 m AMSL) in split plot design having three seed rates (15, 20 and 25q/ha) as main plot and five fertility levels, viz., recommended dose of fertilizer (RDF), FYM at 25t/ha, FYM at 25t/ha + RDF, FYM at 25t/ha + ²/₃ RDF and FYM at 25t/ha + ½ RDF as sub-plots replicated thrice.

The soils of experimental plot was *typic hapludalf* sandy loam rich in organic matter (1.74%), medium in available N (134.2 kg/ha) and K (149.4 kg/ha) and low in available P (6.2 kg/ha) with pH 5.2. The recommended dose of fertilizer for potato was

Table 1. Effect of seed rate and integrated nutrient management on growth attributes of potato.

Treatments	2008					
	Plant emergence (%)	Plant height (cm)	Number of leaves/plant	Number of stems/m ²	Leaf Area index (LAI)	Haulm weight at harvest (q/ha)
Seed Rate (q/ha)						
15	87.13	60.07	38.3	15.4	2.9	73.8
20	88.22	61.11	42.9	19.6	3.4	94.2
25	85.48	65.48	45.8	28.8	3.6	112.9
SE ±	4.5	1.1	1.3	1.7	0.1	3.7
CD (<i>P</i> = 0.05)	NS	3.1	3.7	4.8	0.3	10.4
Fertility Level						
RDF	89.63	60.93	42.8	20.8	3.3	60.6
FYM 25t/ha	84.11	54.18	35.84	21.1	2.6	48.3
FYM 25t/ha + RDF	83.05	67.38	48.6	21.3	3.7	136.0
FYM 25t/ha + ² / ₃ RDF	90.42	64.36	43.7	21.5	3.5	118.8
FYM 25t/ha + ¹ / ₂ RDF	87.51	64.24	40.6	21.8	3.4	104.3
SE ±	3.9	1.1	1.3	1.4	0.05	4.0
CD (<i>P</i> = 0.05)	NS	2.3	2.6	NS	0.1	8.3

Table 1. Continued.

Treatments	2009					
	Plant emergence (%)	Plant height (cm)	Number of leaves/plant	Number of stems/m ²	Leaf area index (LAI)	Haulm weight at harvest (q/ha)
Seed Rate (q/ha)						
15	81.93	52.71	49.20	20.8	3.1	91.25
20	88.89	54.17	54.69	24.3	3.6	101.42
25	91.2	58.17	60.41	32.2	3.9	119.51
SE ±	5.2	0.9	1.5	1.3	0.1	3.4
CD (<i>P</i> = 0.05)	NS	2.6	4.2	3.6	0.3	9.5
Fertility Level						
RDF	87.89	53.87	53.87	25.7	3.5	71.39
FYM 25t/ha	89.78	47.93	48.36	25.8	2.6	57.57
FYM 25t/ha + RDF	88.67	57.91	60.07	25.1	4.0	138.86
FYM 25t/ha + ² / ₃ RDF	84.67	59.27	57.93	26.8	3.7	131.91
FYM 25t/ha + ¹ / ₂ RDF	88.67	56.11	53.62	25.8	3.5	120.57
SE ±	4.7	0.8	1.2	1.14	0.1	4.2
CD (<i>P</i> = 0.05)	NS	1.7	2.4	NS	0.2	8.6

120:52.8:50 kg NPK/ha. Full P and K and half of N as per the treatments were applied at the time of planting as basal dose and rest half of N was top dressed at the time of earthing up. The FYM as per the treatment was applied at the time of planting. The N, P, K and moisture content of FYM used were 0.51, 0.18, 0.58

and 34%, and 0.49, 0.17, 0.56 and 32% during 2008 and 2009 respectively. Well-sprouted healthy tubers of late blight resistant potato cultivar Kufri Girdhari (15—25 g size) was planted during second week of March in both the years at row spacing of 50 cm. The plant to plant spacing was 15 ± 3 cm, 20 ± 3 cm and 27

Table 2. Effect of seed rate and integrated nutrient management on grade wise tuber yield (q/ha) of potato

Treatments	Tuber yield (q/ha) 2008				Tuber yield (q/ha) 2009			
	Large	Medium	Small	Total	Large	Medium	Small	Total
Seed Rate (q/ha)								
15	38.14	44.69	16.01	98.83	49.55	52.78	23.78	126.11
20	61.89	73.53	31.41	166.83	66.31	70.33	36.11	172.76
25	58.35	86.05	36.11	180.50	64.22	78.91	40.78	183.91
SE \pm	2.60	3.72	2.43	4.55	2.44	3.18	2.27	3.93
CD ($P = 0.05$)	7.21	10.32	6.74	12.62	6.78	8.83	6.29	10.92
Fertility								
RDF	52.50	65.82	27.80	146.11	53.33	63.11	34.26	150.70
FYM 25t/ha	29.24	48.43	30.75	108.42	35.00	49.96	41.30	126.25
FYM 25t/ha + RDF	69.89	85.45	25.68	181.02	78.66	83.63	26.76	189.05
FYM 25t/ha + $\frac{2}{3}$ RDF	58.18	72.67	26.92	157.77	70.44	75.33	29.44	175.22
FYM 25t/ha + $\frac{1}{2}$ RDF	54.15	68.07	28.06	150.28	62.70	64.67	36.02	163.39
SE \pm	1.76	2.79	2.10	4.08	1.63	2.36	2.38	4.52
CD ($P = 0.05$)	3.64	5.76	4.33	8.43	3.36	4.87	4.91	9.32

± 3 cm with seed rate of 25, 20 and 15 q/ha respectively. Recommended agronomic package of practices were adopted for potato cultivation. The crop was harvested on full maturity during second week of July. The produce of each plot was graded into large (>75 g), medium (25—75 g) and small (<25 g) size tubers weighed and number counted separately. Economics of cultivation was calculated taking sale price of potato @ Rs 800/q, cost of seed 1,750/q, cost of nutrient viz., N at Rs 10.93 kg, P at Rs 89.16 kg and K at Rs 12.16 kg and FYM at Rs 150/t, other production cost was Rs 40,000/ha.

The average maximum and minimum temperature and rainfall received during crop growth period were 23.2 C and 15.3 C and 23.9 C and 15.2 C and 103.29 and 112.82 cm during 2008 and 2009 respectively. The rainfall was well distributed over the cropping period in both the years.

Results and Discussion

Effect of Seed Rate

Plant emergence ranged from 81 to 93% and was not influenced by seed rate (Table 1). Stems/ha, plant height and haulm weight increased significantly with increase in seed rate and was highest with seed rate of 25 q/ha. Due to decrease in spacing, competition for light between plants probably resulted in taller plants at higher seed rate.

The highest total tuber yield of 180.5 and 183.91 q/ha was recorded with the seed rate of 25 q/ha in 2008 and 2009 respectively. High plant population due to higher seed rate was associated with increased plant stand and more number of shoots per unit area which might have contributed towards better photosynthetic area giving an initial competitive advantage to crop resulting in higher yield. Singh et al. (4) and Malik and Ghosh (5) also reported increased yield with increased seed rate.

The increase in seed rate from 15 to 20 q/ha increased yield of large, medium and small grade tuber in both years (Table 2). However, further increase in seed rate from 20 to 25 q/ha did not increase the tuber yield of different grades significantly during the both years except medium grade tuber yield during 2008. It was further observed that use of higher seed rate produced more medium and small size tubers while low seed rate favored production of large sized tubers. This effect in case of higher seed rate may be attributed to the production of more number of shoots and consequently greater number of tubers because of which the development of tubers was restricted on account of translocation and partition of metabolites to tubers. The tuber yield at lower seed rate was restricted by less number of plants and shoots per unit area resulting in lesser number of tubers per unit area and less inter plant competition favouring the enlargement of tubers.

Table 3. Effect of seed rate and integrated nutrient management on grade wise tuber number (in '000/ha) and average tuber weight of potato.

Treatments	2008				Average tuber weight (g)	2009				Average tuber weight (g)
	Large	Medium	Small	Total		Large	Medium	Small	Total	
Seed Rate (q/ha)										
15	43.8	83.0	85.7	212.6	46.4	58.3	100.7	109.1	268.0	46.8
20	69.9	148.7	149.6	368.2	44.9	80.0	143.2	166.1	389.2	44.2
25	67.8	173.3	181.8	422.8	42.6	77.6	149.2	194.8	421.5	43.5
SE ±	1.1	3.7	4.8	6.8	0.4	1.0	3.5	5.0	7.1	0.3
CD (<i>P</i> = 0.05)	3.1	10.4	13.3	18.9	1.1	2.9	9.8	13.9	19.8	0.8
Fertility										
RDF	62.0	125.8	136.9	324.7	45.1	63.6	122.8	158.1	344.5	44.2
FYM 25t/ha	34.6	105.9	124.0	264.5	41.6	44.0	100.2	185.8	330.0	38.4
FYM 25t/ha+RDF	77.6	156.9	140.8	375.3	48.2	94.1	159.3	130.3	383.7	49.5
FYM 25t/ha+ ² / ₃ RDF	66.1	144.1	145.3	355.4	45.1	83.7	144.7	144.6	373.0	47.2
FYM 25t/ha+ ¹ / ₂ RDF	62.2	142.3	148.2	352.7	43.2	74.3	128.0	164.5	366.8	44.8
SE ±	1.3	4.1	5.7	4.9	0.4	1.1	4.2	5.9	6.4	0.3
CD (<i>P</i> = 0.05)	2.6	8.5	11.7	10.2	0.8	2.3	8.6	12.2	13.3	0.7

Tuber number is related to stems/unit area. The number of plants/unit area increased with increase in seed rate. Therefore, there was significant increase in tuber number with increase in seed rate from 15 to 25q/ha (Table 3). The highest tuber number of medium and small grade was recorded with seed rate of 25 q/ha during both the years. The tuber number of large grade increased with increase in seed rates from 15 to 20 q/ha, however, further increase in seed rate from 20 to 25 q/ha decreased the tuber number of large size. The average tuber weight decreased with increase in seed rate. This showed that with increase in seed rate the contribution of small size tuber to the total tuber number increased thereby reducing the average tuber weight. Tuberization takes place during early growth of potato plant. At this stage it is not much affected by competition caused due to closed spacing. However, at later stages the competition for space increases and availability of photosynthates for tuber growth decreases, which results in restricted growth of the tuber leading to large production of medium and small grade tubers. Kumar et al. (6) also attributed decreased availability of assimilates for individual tubers due to increased plant density, thereby decreasing the number of large and increasing the number of medium and small size tubers.

Effect of Fertility Levels

Fertility levels did not influenced plant emergence and stems/ha (Table 1). Significantly taller plants with more numbers of leaves and haulm weight were recorded with application of FYM at 25t/ha + RDF.

The highest yield and number of large and medium size tuber and total tuber was recorded with application of FYM at 25t/ha + RDF while the highest yield and number of small size tuber and lowest total tuber yield was recorded with the application of FYM at 25 t/ha only (Tables 2 and 3). Application of FYM at 25t/ha + ¹/₂ RDF produced large and medium grade tuber yield as well as total tuber yield at par to sole RDF. Upadhyay and Sharma (7) also obtained higher tuber yield with integrated use of FYM and chemical fertilizer over sole chemical fertilizer. The combined use of FYM and inorganic fertilizer provided adequate available N, P and K in the soil during initial growth stages and met the nutrient requirement of the crop during entire growth period resulting in increased uptake of nutrients (Table 4). The contribution of small size tuber number in the total tuber number increased with decrease in fertility levels consequently decreasing average tuber weight.

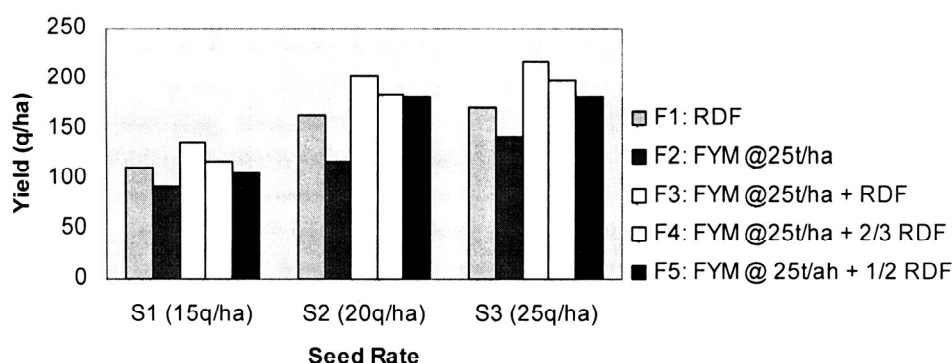


Figure 1. Interaction effect of seed rate and fertility level on potato tuber yield.

The initial fertility status of the soil in terms of available N and K was medium and available P was low, hence the total tuber yield responded significantly to increased rate of fertilizer application. The increase in yield and number of large and medium size tuber was also significant under increased fertility, reflecting that under the higher fertility level, the bulking of small tuber to medium grade tuber and medium grade tuber to large size was more, hence the yield of total as well as large and medium grade tuber improved.

Interaction Effect

The interaction among seed rate and fertility levels was significant. Seed rate at 25q/ha though recorded higher tuber yield over seed rate of 20q/ha in all the fertility levels, the magnitude of increase was relatively greater on higher fertility. There was no significant difference in total tuber yield recorded with seed rate of 20 and 25 q/ha at lower fertility level (F_5) however, total tuber yield increased significantly as the fertility level was increased to F_4 and F_3 (Fig.1). At low fertilizer application rate, the competition for nutrient existed even in widely spaced crop (seed rate of 20 q/ha) which becomes less or absent at higher fertility level even for closely spaced crop (seed rate of 25q/ha). Malik and Ghosh (5) and Garg et al (8) have also reported similarly.

Nutrient Uptake

The increase in seed rate from 15 to 20 q/ha

increased the uptake of N, P and K by 48.5, 51.6, and 47.1% and 50.3, 53.9 and 48.7% during 2008 and 2009, respectively (Table 1). Further, increase in seed rate from 20 to 25q/ha did not increase significantly the N, P and K uptake. This was probably due to higher dry matter production with increasing seed rate.

The uptake of N, P and K was highest with the application of FYM at 25 t/ha + RDF and minimum with application of only FYM at 25 t/ha. The uptake of N, P and K with the application of FYM at 25 t/ha + $\frac{1}{2}$ RDF was at par with the uptake recorded with sole RDF through chemical fertilizers. Higher NPK content at higher fertility level together with higher dry matter production resulted in higher NPK uptake. These results support the findings of Suman et al. (9).

Economics

The cost of cultivation increased with increase in seed rate. Although the gross return was also higher with seed rate of 25q/ha (Rs 1,45,764/) over seed rate of 20q/ha (Rs 135,835) but the net return improved only marginally (Rs 1,179/ha). The beneficial effect of increased gross return (Rs 9,929) on net return was negated due to increased cost of cultivation under seed rate of 25q/ha which was Rs 8,750/ha more over seed rate of 20 q/ha. The benefit : cost ratio was highest (1.55) with seed rate of 20 q/ha followed by seed rate of 25q/ha (1.51). Thus seed rate of 20 q/ha was more economical and remunerative than 25q/ha.

The cost of cultivation was maximum with FYM at 25 t/ha + RDF and minimum with sole RDF. How-

Table 4. Effect of seed rate and integrated nutrient management on nutrient uptake and economics of potato.

Treatments	Nutrient uptake (kg/ha)						Economics			
	2008			2009			Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B : C ratio
N	P	K	N	P	K					
Seed Rate (q/ha)										
15	41.52	4.65	56.60	39.98	4.45	54.64	78702	89955	11253	1.14
20	65.65	7.05	83.27	60.07	6.85	81.27	87452	135835	48383	1.55
25	63.99	7.40	86.03	61.96	7.13	83.45	96202	145764	49562	1.51
SE ±	1.7	0.6	2.3	1.8	0.5	2.4				
CD (<i>P</i> = 0.05)	4.8	1.6	6.4	4.9	1.4	6.8				
Fertility										
RDF	47.24	5.52	63.18	46.95	5.49	62.81	83379	118725	35347	1.41
FYM 25 t/ha	38.41	4.44	51.63	37.16	4.28	50.04	84900	93872	8971	1.10
FYM 25 t/ha + RDF	71.60	8.07	97.35	70.02	7.86	95.35	91491	147992	56500	1.60
FYM 25 t/ha + ² / ₃ RDF	64.12	7.27	86.95	60.73	6.83	82.66	89294	133200	43905	1.48
FYM 25 t/ha + ¹ / ₂ RDF	57.24	6.53	77.39	55.15	6.26	74.75	88196	125468	37272	1.41
SE ±	1.9	0.5	2.5	1.6	0.5	2.3				
CD (<i>P</i> = 0.05)	3.9	1.1	5.2	3.4	1.1	4.7				

ever, the gross return and net return was also maximum with FYM at t/ha + RDF. The increase in net return under FYM at 25 t/ha + RDF was due to significant increase in total tuber yield. The application of FYM at 25 t/ha + ¹/₂ RDF recorded net return and B : C ratio similar to sole RDF.

It may be concluded that small size seed tuber may be planted with seed rate of 20q/ha and fertilized with FYM at 25 t/ha + RDF for obtaining higher productivity and profitability.

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