e-planet **17** (2): 117-122 (December 2019)

Performance of potato (*Solanum tuberosum* L.) with organic inputs in North-Eastern India

J.M. MAWTHOH, LALA I.P. RAY*, A.K. SINGH, N.J. SINGH AND R.S. DHIVYA

School of Natural Resource Management, College of Postgraduate Studies in Agricultural Sciences, CAU-Imphal, Umiam-793103, Meghalaya, India

**lalaipray@rediffmail.com*

Date of receipt: 15.10.2019 Date of acceptance: 17.12.2019

ABSTRACT

A field experiment was conducted under organic regime on potato (*Solanum tuberosum* L.) in mid hills of Meghalaya during 2018-19 at experimental farm of College of Agriculture, Kyrdemkulai, Meghalaya. The treatments included irrigation scheduling and organic manure application, *viz.,* irrigation at sprouting (S_1); irrigation at sprouting + stolonization (S_2); irrigation at sprouting + stolonization + tuber initiation (S_3); irrigation at sprouting + stolonization + tuber initiation + tuber bulking (S_4) and organic treatments comprised of FYM (Farmyard manure) (M_1), poultry manure (M_2) and control (M_0). Tuber yield was found to be significantly higher under S_2 (17.52 t ha^{-1}) yielded the highest followed by S_4 (16.62 t ha^{-1}) and S_3 (14.87 t ha^{-1}), whereas, S_1 (6.61 t ha^{-1}) recorded the lowest yield. Organic manure treatments yielded significant results. M_2 (17.77 t ha^{-1}) showed the highest tuber yield closely followed by M_1 (13.94 t ha^{-1}) and lowest yield was reported by M_0 (10.22 t ha^{-1}). Maximum gross return, net return and BCR were reported in S_2 followed by S_4, S_3 and S_1. In case of organic manure, higher gross return, net return and BCR was recorded in M_2 followed by M_1 and M_0. Benefit Cost Ratio (BCR) also showed significant difference among the organic manure treatments, M_2 (2.82) produced the highest BCR over M_1 (2.13) and M_0 (1.79).

Key words: BCR, irrigation scheduling, organic manure, potato, strip plot design

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important foods in the world ranking fourth in production after rice, wheat and maize. It ranks second in India in terms of production after China (Scott and Suarez, 2011). In Meghalaya, the total area under potato cultivation is 18,473 ha and total production is 1,82,285 metric tonnes. One of the promising varieties of potato is Kufri Megha, grown mainly under irrigated conditions during the *rabi* or *post rabi* season. The north eastern states of India contribute about 10% of the total area under potato in the country and 4% of the total production in India (Gupta et al., 2004). But the potato productivity in this region is very low (8.64 t ha^{-1}) as scientific production technology has not been adopted (Burman et al., 2007).

Potato is highly sensitive to water stress and since it is being cultivated mostly during the *rabi* season, it is of utmost importance for water management through irrigation scheduling techniques for better potato production. Suitable irrigation scheduling during crop's critical stages (stolonization, tuber initiation and tuber bulking) can help farmers to conjunctively use water whilst also increasing the yield. Also, being an exhaustive crop, proper nutrient management needs to be addressed to ensure potential output. Manures improve crop growth by enhancing uptake of nutrients by plants to the soil and improve soil fertility by increasing available nutrients. Organic manure application enhances soil porosity, soil moisture content and water holding capacity (Mahmood et al., 2017).

MATERIALS AND METHODS

A field experiment was conducted during November - March, 2018-19 at the College of Agriculture, Kyrdemkulai, Ri-bhoi district, Meghalaya with "Kufri Megha" potato variety. The experimental site is situated at 91° 18' to 92° 18' East longitude and 25° 40' to 26° 20' North latitude and at an altitude of 950 m above the mean sea level (MSL). The climate of Ri-bhoi is classified as subtropical humid type with high rainfall and cold winters. During the experimentation period, maximum weekly rainfall of 20.9 mm was received during 2nd standard week (January), the total amount of 81.73 mm was received during the crop-growing season. Mean weekly maximum temperature was highest during 11th standard week (27°C) and lowest in 1st standard week (18.20°C). Mean weekly minimum temperature was highest during 11th standard week (13.20°C) and lowest in 1st standard week (5.90°C). The average recorded weekly relative humidity was 90%.

The red clay loam soil has initial organic carbon and pH of 1.8%, 5.1 respectively. The available nitrogen (N), phosphorus (P) and potassium (K) at 0-30 cm were 242.8 kg ha^{-1}, 19.25 kg ha^{-1} and 320 kg ha^{-1}, respectively. Organic manures were incorporated before sowing.

Potato crop is very sensitive to water deficit; hence, it requires frequent and shallow irrigations. Reduction in yield is often associated with water deficit during stolonization, tuber initiation and tuber bulking (FAO, 2008). Taking this into consideration, the criteria based on crop's critical growth stages were utilized for scheduling of irrigations *viz.* Irrigation at sprouting (10 DAS); Irrigation at sprouting (10 DAS) and stolonization (30 DAS); Irrigation at sprouting (10 DAS), stolonization (30 DAS) and tuber initiation (50-55 DAS); Irrigation at sprouting (10 DAS), stolonization (30 DAS), tuber initiation (50-55 DAS) and tuber bulking (65-70 DAS) on respective plots. FYM and poultry manure were applied at the rate of 24 t ha^{-1} and 8 t ha^{-1}, respectively base on recommended nitrogen dose of potato. Seed rate and spacing adopted was 15 t ha^{-1} and 50 cm × 20 cm respectively. First irrigation was given after sowing for inducing germination.

Total of 12 treatments consisted of four irrigation scheduling at critical stages and two organic manures and a control. The experiment was laid in strip plot experimental design. The treatments were given below.

Vertical strips

i. Irrigation at sprouting (10 DAS) (S_1)
ii. Irrigation at sprouting(10 DAS) and stolonization (30 DAS) (S_2)
iii. Irrigation at sprouting(10 DAS), stolonization (30 DAS) and tuber initiation (50-55 DAS) (S_3)
iv. Irrigation at sprouting(10 DAS), stolonization (30 DAS), tuber initiation (50-55 DAS) and tuber bulking (65-70 DAS) (S_4)

Horizontal strips

i. Control (no manure) (M_0)
ii. Farmyard manure (M_1)
iii. Poultry manure (M_2)

The crop calendar is presented in Table 1

Table 1. Calendar of operations

Sl.	Cultural Operation	Date of Operation
1.	Field preparation and incorporation of lime.	14th November 2018
2.	Field layout	17th November 2018
3.	Application of manures	19th November 2018
4.	Sowing	24th November 2018
5.	Gap filling	27th December 2018
6.	Weeding	29th December 2018 (as and when required)
7.	Earthing up	15th January 2019
8.	Harvesting	23rd March 2019

Various plant growth parameters, *viz*., Plant height (cm), weight of tuber per plant, total tuber yield (t ha^{-1}) were estimated as per standard protocols. Cost of cultivation was calculated and accordingly benefit cost ratio (BCR) values were estimated for various treatment combinations.

The data obtained from various studies during investigation were statistically analysed by using the technique of analysis of variance for strip plot design over the computer. The difference between the treatment means was tested as for their statistical significance with appropriate critical difference (C.D.) value at 5% level of probability as explained by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant height

Plant height is an important parameter for determining the growth of plant. The maximum plant height was recorded at 105 DAS 29.98 cm. Plant heights of potato decreases with decrease of irrigation frequency (Kumar et al., 2007). It is readily influenced by the prevailing meteorological conditions during the growing season. At the time of maturity, the maximum plant height recorded was 29.98 cm under poultry manure treatment (M_2). Irrigation scheduling at crops' critical stages, *viz*., irrigation at sprouting (S_1); irrigation at sprouting + stolonization (S_2); irrigation at sprouting + stolonization + tuber initiation (S_3) and irrigation at sprouting + stolonization + tuber initiation + tuber bulking (S_4), did not show significant results on plant height and this may be due to the occurrence of light showers throughout the growing period. However, significant increase in plant height was observed with the application of organic amendments. The application of poultry manure showed the highest plant height (29.98 cm) and the shortest height was recorded under control treatment (23.73 cm) at 105 DAS as shown in Table 1. It might be due to the ability of poultry manure to decompose rapidly thereby, releasing the nutrients essential for plant growth Boateng et al. (2006). Other organic manures including FYM, has slow release of nutrients (Souza et al., 2008). The results reported a significant difference in plant height in plants derived in poultry manure and FYM compared with that of control. These results were in agreement to the findings of Karim et al. (2016). The increase in plant height from 90 DAS to 105 DAS is very small and this is due to the starting of senescence period where growth becomes stagnant.

Yield attributes

Significant results were recorded in irrigation scheduling treatments on weight of tubers per plant. Even so, treatments with only one irrigation, *i.e.,* S_1 produced the lowest weight of tubers per plant. This indicates that water availability at the root zone of plant plays an important role on the final yield. And clearly, irrigation at stolonization proves to be the most critical stage for better crop performance (Table 1). This is in conformity with results reported by Saikia (2011) and Bora and Karmakar (2012). Hence, it can be concluded that the availability of water at root zone during potato growth helps in better yield and produce (Bisht et al., 2012). Among organic manure treatment M_2 (205.91 g) closely followed by M_1 (172.79 g) and M_0 (108.78 g). The findings are in accordance with Lemaga and Caesar (1990), Amara and Mourad (2013) and Karim et al. (2016).

Tuber yield was found to be significantly higher under S_2 (17.52 t ha^{-1}) yielded the highest followed by S_4 (16.62 t ha^{-1}) and S_3 (14.87 t ha^{-1}), whereas, S_1 (6.61 t ha^{-1}) recorded the lowest yield. Organic manure treatments yielded significant results. M_2 (17.77 t ha^{-1}) showed the highest tuber yield closely followed by M_1 (13.94 t ha^{-1}) and lowest yield was reported by M_0 (10.22 t ha^{-1}). Crop irrigated only at sprouting might have experienced water stress during the vegetative phase, reproduction phase and maturity phase causing a reduction in final tuber yield. The reduction in yield with treatment S_1 can also be attributed to the lesser number of tubers per plant and lower tuber weight per plant. High water requirement needs to be emphasized especially during potato critical stages of stolonization, tuber initiation and tuber bulking (Hassan et al., 2002; Saikia, 2011; Bora and Karmakar, 2012). Among organic manure treatment M_2 (17.77 t ha^{-1}) closely followed by M_1 (13.94 t

ha^{-1}) and M_0 (10.2 t ha^{-1}). Poultry manure has been reported to have a favourable effect on soil physical, chemical and biological properties (Demir et al., 2010; Oustani et al., 2015). The yield of potato is favourably higher under manure fertilisation and this may be attributed to the improvement of soil water retention and supplementation of required nutrient. Under control treatment, the yield is extremely low due to a smaller number of tubers, small tuber size and low weight of tubers per plant. These findings are in line with those reported by Chandrakar et al. (2017).

Table 2. Effect of irrigation scheduling and organic manures on performance of potato

Treatments	Plant height (cm)	Weight of tuber per plant (g)	Tuber yield (t ha^{-1})	Gross Return	Net Return	BCR
S_1	25.02	156.92	6.61	106777.78	12782.42	1.13
S_2	28.05	169.01	17.52	271511.11	176483.25	2.83
S_3	26.89	161.62	14.87	230888.89	134828.53	2.39
S_4	26.85	162.45	16.62	257511.11	160418.25	2.63
S.E. (m) ±	0.58	3.11	0.37	5444.97	5444.97	0.06
C.D (P=0.05)	NS	NS	1.27	18839.24	18839.24	0.20
M_0	23.73	108.81	10.02	156362.50	69353.73	1.79
M_1	26.40	172.79	13.94	217945.83	116069.06	2.13
M_2	29.98	205.91	17.77	275708.91	177961.56	2.82
S.E. (m) ±	0.38	2.25	0.24	3535.91	3535.91	0.04
C.D (P=0.05)	1.49	8.91	0.74	13881.61	13881.61	0.14

*NS= Non significant

Economics

Gross return reported significant results under irrigation scheduling treatments, S_2 (₹ 2,71,511 ha^{-1}) recorded highest gross return over S_4 (₹ 2,57,511 ha^{-1}) followed by S_3 (₹ 2,30,889 ha^{-1}) and S_1 (₹ 1,06,778 ha^{-1}) being the lowest. For net return S_2 (₹ 1,76,483 ha^{-1}) recorded the highest net return closely followed by S_4 (₹ 1,60,418 ha^{-1}) followed by S_3 (₹ 1,34,829 ha^{-1}) and S_1 (₹ 12,782 ha^{-1}) being the lowest. BCR also showed significant difference among the irrigation scheduling treatments, S_2 (2.83) produced the highest BCR over S_4 (2.63) and S_3 (2.39) but the lowest is S_1 (1.13). Similar findings were reported by Bisht et al. (2012) and Chandrakar et al. (2017). For organic manure treatment, significant results were reported from gross return, net return and BCR. Gross return of M_2 (₹ 2,75,709 ha^{-1}) showed significantly higher results compared to M_1 (₹ 2,17,946 ha^{-1}) and M_0 (₹ 1,56,363 ha^{-1}). For net return, M_2 (₹ 1,77,962 ha^{-1}) showed significantly higher results compared to M_1 (₹ 1,16,069 ha^{-1}) and M_0 (₹ 69,354 ha^{-1}). BCR also showed significant difference among the organic manure treatments, M_2 (2.82) produced the highest BCR over M_1 (2.13) and M_0 (1.79). This can be attributed to the significantly larger amount of yield reported from poultry manure and FYM treatments over control treatment.

Table 3. Economics of potato cultivation under organic regime

	Cost of cultivation (₹ ha^{-1})											
Operation (s)	S_1M_0	S_1M_1	S_1M_2	S_2M_0	S_2M_1	S_2M_2	S_3M_0	S_3M_1	S_3M_2	S_4M_0	S_4M_1	S_4M_2
A. Fixed cost												
Land rent	8,330	8,330	8,330	8,330	8,330	8,330	8,330	8,330	8,330	8,330	8,330	8,330
Pump hiring cost for irrigation	1,000	1,000	1,000	2,000	2,000	2,000	3,000	3,000	3,000	4,000	4,000	4,000
Miscellaneous	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total fixed cost (A)	10,330	10,330	10,330	11,330	11,330	11,330	12,330	12,330	12,330	13,330	13,330	13,330
B. Variable cost												
Primary tillage	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Spading	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610
Lay out	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760
Seed cost	40,500	40,500	40,500	40,500	40,500	40,500	40,500	40,500	40,500	40,500	40,500	40,500
Sowing	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760
Gap filling	690	690	690	690	690	690	690	690	690	690	690	690
Weeding	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450	3,450
Earthing	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300
Dehaulming	690	690	690	690	690	690	690	690	690	690	690	690
Harvesting	2760	2760	2760	2760	2760	2760	2760	2760	2760	2760	2760	2760
Manure cost	0	14,400	10,400	0	14,400	10,400	0	14,400	10,400	0	14,400	14,400
Lime	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Application labour charge	920	920	920	920	920	920	920	920	920	920	920	920
Plant protection measures using organic input	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Miscellaneous	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total variable cost (B)	72,440	86,840	82,840	72,440	86,840	82,840	72,440	86,840	82,840	72,440	86,840	86,840
Sub-Total (A+B)	82,770	97,170	93,170	83,770	98,170	94,170	84,770	99,170	95,170	85,770	1,00,170	1,00,170
C. Interest on working capital	2690.025	3158.025	3028.025	2722.525	3190.525	3060.525	2755.025	3223.025	3093.025	2787.525	3255.525	3255.525
Total cost of cultivation (A+B+C)	85,460.03	1,00,328.03	96,198.03	86,492.53	1,01,360.53	97,230.53	87,525.03	1,02,393.03	98,263.03	88,557.53	1,03,425.53	1,03,425.53

CONCLUSION

Irrigation scheduled at sprouting + stolonization (S_2) is the most suitable for better performance and better economics of potato. It may be concluded that among the organic amendments treatments there is significant differences in the yield and in BCR therefore, poultry manure may be preferred over the other manures.

ACKNOWLEDGEMENT

The authors would like to thank Central Agricultural University, Imphal for the financial support for the study. Thanks are due to the Dean, College of Agriculture, Kyrdemkulai (CAU, Imphal) for providing all logistic support during the field trial. The authors would like to appreciate the Dean, College of Post Graduate Studies in Agricultural Sciences and all the research committee advisory members for their timely suggestions and help.

REFERENCES

Bisht, P., Raghav, M. and Singh V.K. 2012. Effect of different irrigation schedules on the growth and yield of drip irrigated potato. *Potato J.* **39**(2): 202-204.

Boateng, S.A., Zickermann, J. and Kornahrens, M. 2006. Poultry manure effect on growth and yield of maize. *West Afr. J. Appl. Ecol.* **9**: 12-18.

Bora, P.K. and Karmakar, R.M. 2012. Productivity of potato under limited irrigation regime in relation to weather parameters. *Indian J. Dryland Agric. Res. Dev*. **27**(1): 52-57.

Burman, R.R., Kumar, M. and Nagaraj, K.M. 2007. Organic potato production- practices and extension strategy. In: *Advances in Organic Farming Technology in India*, (eds.) G.C. Munda, P.K. Ghosh, A. Das, S.V. Nagchan and K.M. Bujarbaruah, ICAR Research Complex for NEH Region. Umiam, India, pp. 271–279.

Chandrakar, C.K., Shrivastava, G.K., Dwivedi, S.K., Sharma, D., Pandey, K.K. and Singh, S.K. 2017. Advance Agro-techniques for yield efficiency and economics of potato (*Solanum tuberosum*) crop for Chhattisgarh Plains. *Int. J. Curr. Microbiol. App. Sci.* **6**(2): 766-777.

Demir, K., Sahin, O., Kadioglu, Y.K., Pilbeam, D.J. and Gunes, A. 2010. Essential and nonessential element composition of tomato plants fertilized with poultry manure. *Sci. Horti.* **127**: 16-22.

FAO. 2008. *Potato and water resources.* http://www.potato2008.org/ Accessed 2 June 2019.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical procedure for agriculture research*. 2nd Edn. International Rice Research Institute, Los Banos, Philipines. John Wily and Sons, New York. p. 324.

Gupta, V.K., Thakur, K.C., Kumar, S., Pandey, S.K. and Sah, U. 2004. *True Potato Seed- An alternative technology for potato production in North eastern hill region*. Technical bulletin no 64. Central Potato Research Institute, Shimla. p. 1.

Hassan, A.A., Sarkar, A.A., Ali, M.H. and Karim, N.N. 2002. Effect of deficit irrigation at different growth stages on yield of potato. *Pakistan J. Biol. Sci.* **5**(2): 128-134.

Karim, K.H., Maful, M.T. and Mahmut, F.M. 2016. Effect of different poultry and cattle manure rates on yield and yield components of potato (*Solanum tuberosum*) cv- Sante. *Egypt. J. Biol. (Bot.)*. **12** (2): 155-162.

Kumar, P., Pandey, S.K., Singh, S.V. and Kumar, D. 2007. Irrigation requirements of chipping potato cultivars under west-central Indian plains. *Potato J.* **34**(3-4): 193- 198.

Lemaga, B. and Caesar, K. 1990. Relationships between numbers of main stems and yield components of potato (*Solanum tuberosum* L. cv. Erntestolz) as influenced by different day lengths. *Potato Res.* **33**: 257-267.

Mahmood, F., Khan, I., Ashraf, U., Shahzad, T., Hussain, S., Shahid, M., Abid, M. and Ullah, S. 2017. Effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties. *J. Soil Sci. Plant Nutr.* **17**(1): 22-32.

Oustani, M., Halilat, M.T. and Chenchouni, H. 2015. Effect of poultry manure on the yield and nutriments uptake of potato under saline conditions of arid regions. *Emir. J. Food Agric*. **27**(1): 106-120.

Saikia, M. 2011. Effect of irrigation and mulching on growth, yield and water use efficiency of potato in Assam. *Potato J.* **38**(1): 81-83.

Scott, G. and Suarez, V. 2011. Growth rates for potato in India 1961-2009 and their implications for industry. *Potato J.* **38**(2): 100-112.

Souza, P.A., Souza, G.L.F.M., Menezes, J.B. and Bezerra, N.F. 2008. Evaluations of cabbage cultivar grown under organic compost and mixed mineral fertilizers. *Hortic. Bras.* **26**: 143-145.