Original Research Article

Impact of various Nitrogenrates on the Performance of winter Potato (var. *KufriSindhuri*) in Valley areas of Manipur, India

Abstract

Experiments conducted at College of Agriculture, Central Agricultural University, Imphal during the winter seasons of 2017-18 and 2018-19 recorded the performance of potato variety KufriSindhuri under three different nitrogen rates- 120 kgha^{-1} (N_1), 100 kgha^{-1}(N_2) and 80 kgha^{-1}(N_3) using drip irrigation. The results indicated that plants fertilized with120 kgha^{-1} nitrogen recorded maximum germination percentage (86.17%), plant height (40.47cm), number of shoots plant^{-1} (4.50), stem girth (0.56cm), crop growth rate (17.96gm^{-2}day^{-1}), relative growth rate (2.75gg^{-1}day^{-1}), weight of tubers per plant (1.04kg) and tuber yield (19.96t/ha) amongst other treatments.

Keywords: Potato, nitrogen, growth parameters, crop growth rate, relative growth rate, tuber yield

Introduction

Potato is an important crop of the world and fulfils all the criteria for a healthy food and offers a great potential for decreasing global food crisis. Hence, it is rightly called as the “poor man’s friend” and was officially dubbed the “Food of the Future” at the event of the United Nations International Year of Potato in Cusco, Peru in 2008. For human consumption it can substitute the cereals to a greater extent. It is used in day to day food menu of almost all Indian recipe. Potato is rich in vitamins especially C and B_1, proteins, carbohydrates, enzymes and other substances necessary for human nutrition. It contains 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fibre and 0.9% ash on dry weight basis (Singh *et al.*, 2008)[1]. It also contains good amount of essential amino acids like leucine, tryptophan and isoleucine. The consumption per capita per year ranges from 55kg in the most affluent countries to 11kg in developing countries (Fabeiro*et al.*, 2001)[2]. Apart from daily usage as vegetable, it is also used for several industrial purposes, *viz.*, production of starch, alcohol, dextrin, glucose, dyes *etc*. Potato starch (farina) is used in laundries and for sizing yarn in textile mills.It is one of the most remunerative and profitable crop for the growers due to its higher yield potential within a limited time. Though in the past, it was a labour oriented crop but due to mechanization it can be grown in large areas with low labour requirement. This is a crop, which can be adopted in cropping system and helps in increasing the cropping intensity to a greater extent. The wide flexibility in its planting and harvesting dates makes the crop most suitable for inclusion in intensive cropping system.In India, potato is not primarily a rural staple food, rather a cash crop that provides significant income for small and marginal farmers. Since 1990, its per capita consumption has risen from around 12kg to 17kg a year. Due to high demand and production growth scenario, almost 80% of the additional potato output in developing countries will be realized in China and India (Scott *et al.*, 2000)[3]. It is also reported that the most rapid annual potato market growth (3.8%) is expected in India (Guenthner, 2010)[4]. Thus, with proper management techniques if potato production in our country can be further increased then it would help to sustain food and nutrition security, reduce the need of imports of cereals and save precious foreign exchange.

Comment [M1]: Reference format as per journal?

North Eastern Hill (NEH) region of India especially under the hilly tracts, where potato is an important crop is grown under rainfed conditions (Sah*et al.*, 2011)[5]. The crop assumes immense importance in the cropping system and dietary habits of the people of this region. The NEH region covers almost 10% of the country's total potato area. Potato is a temperate crop and grows well during *rabi* season, but under sub-tropical areas also it can be cultivated successfully. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of root zone. Low productivity of potato in Manipur may be attributed due to the lack of optimum water availability during the growing season. The foremost challenge in successful potato production in this region is the lack of awareness of farmers to apply the new technology and proper nutrient management, Hence, a field trial using different levels of nitrogen application using drip system of irrigation was taken up to ascertain the performance of potato.

Materials and Methods

Comment [M2]: Cite reference form recent literature

Comment [M3]: Statistical analysis details were missing

The experiment was conducted at the experimental field of College of Agriculture, Central Agricultural University, Imphal during the winter season of 2017-18 and 2018-19 and laid out in factorial randomized block design with three replications. The soil of the experimental field was studied by the Bouyoucos Hydrometer method (Chopra and Kanwar,1976)[6] and recorded clayey. It had a pH of 5.29 which was determined by the glass electrode pH meter (Jackson, 1973)[7]. The organic carbon content was determined by Walkley and Black rapid titration method (Piper, 1966) [8] and was reported to be high (2.23%). Available nitrogen (282.73 kgha^{-1}), phosphorous (24.45 kgha^{-1}) and potassium (269.38 kgha^{-1}) were all recorded to be in the medium range and they were determined by the Alkaline permanganate method (Subbiah and Asija, 1956)[9], Bray and Kurtz method (Jackson, 1973)[7] and Flame Photometer method (Jackson, 1973)[7] respectively. The meteorological observations were collected from the Experimental Agromet Advisory Service, ICAR Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal. The mean minimum and maximum temperature recorded during the cropping season was 4.6-6.5ºC and 27.7-29.4ºC, respectively. The total rainfall recorded was 458.40.8 mm. The average relative humidity ranged from 36.6% (minm.) to 93.8% (maxm.). The experiment was laid out in factorial randomized block design and replicated thrice consisting of three nitrogen rate treatments viz., 120 kgha^{-1} nitrogen (N_1) 120 kgha^{-1} nitrogen (N_2) and 120 kgha^{-1} nitrogen (N_3) respectively. Recommended dose of N, P and K (120/100/80: 80: 60 Kg N, P_2O_5 and K_2O kgha^{-1}) was applied in the form of Urea, SSP and MOP respectively. The entire quantity of fertilizer was applied at the time of sowing to all the plots equally. Bold and healthy potato tubers of variety *KufriSindhuri* were selected for planting.

Comment [M4]: N1, N2, N3 seems to be same.

Results and Discussion

Germination:

Comment [M5]: Only result was found. Not discussed with literature

Highest germination was observed in 120 kgha^{-1} nitrogen (N_1) (86. 17%) followed by 100 kgha^{-1} nitrogen (N_2) (82.67%) and 80 kgha^{-1} nitrogen (N_3) (79.78%) for both the years of study as well as on the mean pooled data. This may be because of availability of suitable amount of nitrogen in soil during its emergence period. But the tubers planted with 80 kgha^{-1} nitrogen (N_3) registered lowest germination percentage because of less availability of nitrogen during the initial 30 DAS, which were not very conducive for rapid germination.This is depicted in Table 1.

Table 1: Effect of nitrogen rates on the germination (%) of potato

Treatments	Germination (%) 30 DAS		
	2017-18	2018-19	Pooled

N_1	85.89	86.44	86.17
N_2	81.67	83.67	82.67
N_3	79.56	80.00	79.78
SEd(±)	**1.40**	**1.45**	**1.61**
CD(p=0.05)	**2.85**	**2.96**	**3.27**

Comment [M6]: Expansion missing

Comment [M7]: Expansion missing

Plant height:

Among irrigation regimes, 120 kgha^{-1} nitrogen (N_1) produced significantly taller plants as compared to 100 kgha^{-1} nitrogen (N_2) and 80 kgha^{-1} nitrogen (N_3) at all levels of crop growth. At 30 DAS N_1 (15.95) recorded higher plant height than N_2 (15.47) and N_3 (13.91). N_1 was at par with N_2. At 60 DAS, N_1 (24.41) recorded significantly highest plant height over N_2 (23.93) and N_3 (23.02). N_2 and N_3 were at par. At 90 DAS, N_1 (40.47) showed significantly highest plant height over N_2 (38.21) and N_3 (34.96); Similarly at maturity, N_1 (40.47) produced highest plant height over N_2 (38.55) and N_3 (35.26). This is depicted in Table 2. The N fertilization treatments showed an increase in plant height with an increase in nitrogen rate. The same result was found by previous research (Tolessa*et al.*, 2017[10]; Godebo and Belay, 2020[11]; Setu and Mitiku, 2020[12]).

Table 2: Effect of nitrogen rates on the plant height of potato

Treatments	30 DAS			60 DAS			90 DAS			Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
N_1	15.81	16.08	15.95	24.29	24.53	24.41	40.13	40.80	40.47	40.13	40.80	40.47
N_2	15.29	15.53	15.47	23.79	24.07	23.93	38.21	38.78	38.55	38.21	38.78	38.55
N_3	13.56	14.26	13.91	22.91	23.14	23.02	34.96	35.55	35.26	34.96	35.55	35.26
SEd(+)	**0.30**	**0.30**	**0.31**	**0.50**	**0.49**	**0.47**	**0.66**	**0.67**	**0.69**	**0.66**	**0.67**	**0.69**
CD(p=0.05)	**0.61**	**0.62**	**0.63**	**1.02**	**1.00**	**0.96**	**1.35**	**1.37**	**1.39**	**1.35**	**1.37**	**1.39**

Number of shoots per plant:

120 kgha^{-1} nitrogen (N_1) produced significantly higher number of shoots per plant of potato as compared to 100 kgha^{-1} nitrogen (N_2) and 80 kgha^{-1} nitrogen (N_3) at all levels of crop growth. At 30 DAS N_1 (2.00) recorded higher number of shoots per plant than N_2 (1.78) and N_3 (1.29) for both the years. At 60 DAS, N_1 (3.94) recorded significantly highest number of shoots per plant over N_2 (3.22) and N_3 (2.50). At 90 DAS, N_1 (4.50) showed significantly highest number of shoots per plant over N_2 (3.74) and N_3 (2.81); Similarly at maturity, N_1 (4.50) produced highest number of shoots per plant over N_2 (3.74) and N_3 (2.81).The number of shoots plant^{-1} increased with an increase in nitrogen rate. Similar such results were also reported by (Satognon*et al*, 2021)[13]. Yet, at later stages the stem number increased at a decreasing rate. This is depicted in Table 3.

Table 3: Effect of nitrogen rates on the number of shoots per plant of potato

Treatments	30 DAS			60 DAS			90 DAS			Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
N_1	1.75	2.25	2.00	4.03	3.86	3.94	4.69	4.31	4.50	4.50	4.31	4.50
N_2	1.69	1.86	1.78	3.28	3.17	3.22	3.83	3.64	3.74	3.74	3.64	3.74
N_3	1.25	1.33	1.29	2.50	2.50	2.50	2.75	2.86	2.81	2.81	2.86	2.81
SEd(+)	**0.06**	**0.08**	**0.08**	**0.13**	**0.14**	**0.15**	**0.11**	**0.15**	**0.13**	**0.15**	**0.15**	**0.15**
CD(p=0.05)	**0.11**	**0.17**	**0.16**	**0.26**	**0.27**	**0.30**	**0.23**	**0.30**	**0.26**	**0.30**	**0.30**	**0.30**

Stem girth:

Comment [M8]: Not discussed with literature

Among irrigation regimes, 120 kgha^{-1} nitrogen (N_1) produced significantly higher stem girth (cm) of potato as compared to 120 kgha^{-1} nitrogen (N_2) and 120 kgha^{-1} nitrogen (N_3) at all levels of crop growth. This is depicted in Table 4. At 30 DAS N_1 (0.41) recorded higher number of shoots per plant than N_2 (0.38) and N_3 (0.35) for both the years. At 60 DAS, N_1 (0.55) recorded significantly highest number of shoots per plant over N_2 (0.50) and N_3 (0.43). N_2 and N_1 were at par. At 90 DAS, N_1 (0.66) showed significantly highest number of shoots per plant over N_2 (0.62) and N_3 (0.53) but N_1 was at par with N_2; Similarly at maturity, N_1 (0.56) produced highest number of shoots per plant over N_2 (0.52) and N_3 (0.43).Nitrogen, which promotes the formation of stems and leaves in the plant, is a nutrient that directly affects the important physiological functions in the plant and amount as well as the quality of product.Hence, the stem girth increased with an increase in nitrogen rate.

Table 4: Effect of nitrogen rates on the stem girth of potato

Treatments	30 DAS			60 DAS			90 DAS			Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
N_1	0.37	0.46	0.41	0.50	0.61	0.55	0.61	0.71	0.66	0.51	0.61	0.56
N_2	0.34	0.42	0.38	0.44	0.56	0.50	0.56	0.68	0.62	0.46	0.58	0.52
N_3	0.31	0.39	0.35	0.36	0.50	0.43	0.46	0.60	0.53	0.36	0.50	0.43
SEd(+)	**0.015**	**0.018**	**0.017**	**0.019**	**0.024**	**0.022**	**0.023**	**0.019**	**0.024**	**0.021**	**0.019**	**0.020**
CD(p=0.05)	**0.031**	**0.036**	**0.034**	**0.039**	**0.050**	**0.044**	**0.047**	**0.039**	**0.048**	**0.042**	**0.039**	**0.040**

Crop growth rate:

Among irrigation regimes, 120 kgha^{-1} nitrogen (N_1) produced significantly more CGR (gm^{-2}day^{-1}) of potato as compared to 100 kgha^{-1} nitrogen (N_2) and 80 kgha^{-1} nitrogen (N_3) at all levels of crop growth. This is depicted in Table 5. At 30-60 DAS N_1 (5.86) recorded higher CGR (gm^{-2}day^{-1}) than N_2 (4.63) and N_3 (4.21) for both the years. At 60-90 DAS, N_1 (17.96) recorded significantly highest CGR (gm^{-2}day^{-1}) over N_2 (15.55) and N_3 (9.75); However, during 90 DAS-maturity, N_2 (16.30) produced significantly highest CGR (gm^{-2}day^{-1}) over

N_3(16.27) and N_1 (15.08) but N_2 was at par with N_3.The nitrogen levels performance had significant effect on CGR at all the stages of crop growth due to the suitability of the climatic conditions for growth and development. During 90 DAS-maturity, the CGR was slowed down, because of falling of the old leaves (Isoda*et al.*, 1987[14]; Borego*et al.*, 2000[15]; Fonseka*et al.*, 1996[16]).

Table 5: Effect of nitrogen rates on the Crop Growth Rate of potato

Treatments	30-60 DAS			60-90 DAS			90 DAS-Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
N_1	5.83	5.89	5.86	17.85	18.07	17.96	14.91	15.35	15.08
N_2	4.63	4.69	4.66	15.44	15.66	15.55	15.91	16.59	16.30
N_3	4.21	4.29	4.25	9.69	9.81	9.75	16.22	16.32	16.27
SEd(+)	**0.134**	**0.135**	**0.120**	**0.545**	**0.624**	**0.332**	**0.312**	**0.379**	**0.354**
CD(p=0.05)	**0.271**	**0.275**	**0.244**	**1.108**	**1.267**	**0.675**	**0.633**	**0.771**	**0.719**

Relative Growth rate:

Among irrigation regimes, 120 kgha^{-1} nitrogen (N_1) produced significantly more RGR (gg^{-1}day^{-1}) of potato as compared to 100 kgha^{-1} nitrogen (N_2) and 80 kgha^{-1} nitrogen (N_3) at all levels of crop growth. This is depicted in Table 6. During 30-60 DAS N_1 (2.30) recorded higher RGR (gg^{-1}day^{-1}) than N_2 (2.25) and N_3 (2.12) for both the years. During 60-90 DAS, N_1 (2.75) recorded significantly highest RGR (gg^{-1}day^{-1}) over N_2 (2.69) and N_3 (2.58). However, during 90 DAS-maturity there was non-significant interaction between the treatments.RGR was found significantly higher in N_1 over, N_2 and N_3 and went on increasing from 30-60 DAS upto 90DAS-Maturity. These results are in line to the findings of Walker *et al.*, 2001[17]. They recorded that growth rate is controlled by the rate of external N supply. Where external N is available the amount of N taken up by the plant increases linearly with its dry weight, so that plant N concentration remains constant, with all of the nitrate converted into organic forms of N virtually as soon as it is taken up and transported to the shoots.

Table 6: Effect of nitrogen rates on the Relative Growth Rate of potato

Treatments	30-60 DAS			60-90 DAS			90 DAS-Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
N_1	2.30	2.30	2.30	2.75	2.76	2.75	2.95	2.96	2.96
N_2	2.24	2.25	2.25	2.69	2.69	2.69	2.93	2.94	2.94
N_3	2.18	2.19	2.19	2.57	2.58	2.58	2.87	2.87	2.87
SEd(+)	**0.038**	**0.042**	**0.040**	**0.051**	**0.045**	**0.045**	**0.049**	**0.049**	**0.052**

CD(p=0.05)	**0.077**	**0.085**	**0.082**	**0.103**	**0.091**	**0.091**	**NS**	**NS**	**NS**

Weight of tubers per plant

Among irrigation regimes, 120 kgha^{-1} nitrogen (N_1) produced significantly more weight of tubers per plant (kg) of potato (1.04) as compared to 100 kgha^{-1} nitrogen (N_2) (0.97) and 80 kgha^{-1} nitrogen (N_3) (0.85) at the time of harvest for both the years of study and the pooled data.(Beycioğlu, *et al.*, 2021[18]and Wang *et al.*,2020[19]) also reported that potato tuber yield, largest tuber weight, commodity tuber weight, dry matter accumulation, and vitamin C content increased with the increase in the fertilizer application rate and the dripper discharge rate. Arnout, (2001)[20] revealed that high rates of applied nitrogen can increase tuber weight.This is depicted in Table 7.

Table 7: Effect of nitrogen rates on the Weight of tubers per plant

Treatments	Weight of tubers per plant (kg)		
	2017-18	2018-19	Pooled
N_1	1.03	1.05	1.04
N_2	0.96	0.98	0.97
N_3	0.84	0.86	0.85
SEd(+)	**0.02**	**0.02**	**0.02**
CD(p=0.05)	**0.03**	**0.03**	**0.03**

Tuber Yield

Among irrigation regimes, 120 kgha^{-1} nitrogen (N_1) produced significantly more tuber yield (t ha^{-1}) of potato (19.96) as compared to 100 kgha^{-1} nitrogen (N_2) (18.28) and 80 kgha^{-1} nitrogen (N_3) (16.49) at the time of harvest.Among all factors influencing potato yield, fertilizer application is considered a major one (Westermann,2005)[21]. Nitrogen affects yield and yield components of potato crop (Kundu*et al.*, 2019[22]; Coast *et al.*, 2020[23]). Adequate supply of nitrogen enhanced root growth, uptake of other nutrients, overall development of the crop plants and tuber yield (Brady and Weil, 2008[24]). This is depicted in Table 8.

Table 8: Effect of nitrogen rates on the Tuber Yield of potato

Treatments	Tuber Yield (t ha^{-1})		
	2017-18	2018-19	Pooled
N_1	19.05	20.92	19.96
N_2	18.04	18.63	18.28
N_3	16.35	16.63	16.49
SEd(+)	**0.41**	**0.59**	**0.45**

CD(p=0.05)	0.83	1.21	0.91

Conclusion

Among all the water regime treatments, significantly higher plant growth and yield parameters was obtained by maintaining irrigation regime at 120 $kgha^{-1}$ nitrogen (N_1) followed by 100 $kgha^{-1}$ nitrogen (N_2). It is worth to note that 80 $kgha^{-1}$ nitrogen significantly decreased crop growth and yield (N_3). This study reflects that when winter potato is planted with N_1 in Manipur region using drip irrigation technique, it can prove to be economically profitable to the farmers of this region. So, for yield optimization, growing potato with appropriate irrigation regime is very critical as then we can get healthy plants with good growth and yield. N_1 had higher germination percentage, plant height, number of branches $plant^{-1}$, stem girth, crop growth rate, relative growth rate, weight of tubers per plant, tuber yield amongst other treatments.

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