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Response of Potato (*Solanum tuberosum* L.) to Split Application of Nitrogen under North Gujarat Agro-Climatic Condition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *rabi* 2018-19 and 2019-20 to study the effect of split application of nitrogen under mini sprinkler system on potato yield and economics in North Gujarat Agro-climatic condition on loamy sand soil at Potato Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa. The Recommended dose of fertilizer (RDF) of potato for North Gujarat is 275:138:275 NPK kg/ha. The results revealed that the significantly higher total tuber yield (67.81 t/ha) and net return (`206104/ha) was recorded in 50 % N (103 kg) as basal and remaining 50 % N (103 kg) in two equal splits at 30 and 45 DAP along with 110 P_2O_5 and 275 kg K_2O/ha as basal application with saving of 25 % N under North Gujrat Agro-climatic condition of Gujarat.

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1. INTRODUCTION

"Potato being a member of the *Solanaceae* family and is one of the world's most important food crops" [1]. "It is grown and consumed as a vegetable or as a process products all around the world. It is one of the main vegetable cash crop. Potato is an integral part of the human diet. The area and production of Potato in the country during 2021-22 was estimated around 22.48 lakh ha and 542.30 lakh MT, respectively" [2]. "The major potato growing states are Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab, and Assam. Gujrat ranks fourth after UP, WB and Bihar which produce 39.21 lakh MT of potato from nearly 1.28 lakh ha area with an average productivity of 30.46 t/ha in the year 2021-22" [3]. "Gujarat having high productivity due to high density planting and use of micro irrigation system. Potato is a short duration, high yielding and nutrient exhaustive crop. Use of balanced fertilizers with best management practices is necessary and pre-requisite to get better tuber yield of the crop. One of the foremost management priorities in potato cropping systems is the application of nitrogen which determines the quantity, yield, chemical composition and quality of tuber" [4]. "The plant responses to different nitrogen levels can be justified by vigorous growth, increased leaf area, large tuber size as well as their number. In the deficiency of nitrogen the plants remain stunted with only a few thin stems and few tubers, which ultimately lead to the lesser yield. On the other hand, excess nitrogen application increases environmental losses of nitrogen, including nitrate leaching to groundwater and emissions of nitrous oxide, a major greenhouse gas in the atmosphere. Since nitrogen is highly mobile, its use and demand is continuously increasing as it is subjected to high loss from the soil plant system" [5]. "Even under best management practices, approximately 30-50% of applied nitrogen is lost through different agencies and hence, the farmer is compelled to apply more than what the crop needs to compensate for losses through leaching, volatilization, and denitrification making the nutrient unavailable during the critical stages of crop growth" [6,7].

"Many strategies have been developed to mitigate nutrient leaching and improve nutrient use efficiency. Timing of fertilizer application and manipulation of fertilizer rates are low-cost strategies for reducing nutrient leaching so that nutrient supply is synchronized with plant nutrient demand" [8]. "Split application of nitrogen is one of the strategies of improving nitrogen use by the crops" [9]. Jamaati *et al*. [10] reported "overall improvement in yield as an additional advantage of splitting nitrogen". Keeping these in views a field experiment was conducted to standardize the nitrogen schedule to enhance growth and yield of potato.

2. MATERIALS AND METHODS

Field experiments were conducted at Potato Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa (Gujarat) during *rabi* of 2018-19 and 2019-20. The soil of the experimental site was sandy loam in texture, low in organic carbon (0.35%), pH (7.54), available nitrogen (130 kg N/ha), medium in available phosphorus (45.28 kg P_2O_5/ha) and available potassium (208.53 kg K_2O/ha).

The experiment was laid out in randomised block design with three replications comprising sixteen treatments *viz.*, T_1 : 50 % basal + 50 % split and one split (30 DAP), T_2 : 50 % basal + 50 % split and two split (30 and 45 DAP), T_3 : 50 % basal + 50 % split and three split (30, 45 and 60 DAP), T_4 : 50 % basal + 50 % split and four split (30, 40, 50 and 60 DAP), T_5 : 50 % basal + 50 % split and five split (30, 40, 50, 60 and 70 DAP), T_6 : 25 % basal + 75 % split and one split (30 DAP), T_7 : 25 % basal + 75 % split and two split (30 and 45), T_8 : 25 % basal + 75 % split and three split (30, 45 and 60 DAP), T_9 : 25 % basal + 75 % split and four split (30, 40, 50 and 60 DAP), T_{10}: 25 % basal + 75 % split and five split (30, 40, 50, 60 and 70 DAP), T_{11} : No basal + 100 % split and one split (30 DAP), T_{12} : No basal + 100 % split and two split (30 and 45 DAP), T_{13} : No basal + 100 % split and three split (30, 45 and 60 DAP), T_{14} : No basal + 100 % split and four split (30, 40, 50 and 60 DAP), T_{15} : No basal + 100 % split and five split (30, 40, 50, 60 and 70 DAP) and T_{16} : 100% RDN (275 kg N /ha) with Kufri Pukhraj cultivar. In case of split of nitrogen (75 % RDN) was applied in treatment T_1 to T_{15} and RDF :275 kg N/ha, 110 P_2O_5 : 275: K_2O kg /ha was applied as common dose. The crop was irrigated by mini sprinkler system. Ammonium sulphates, urea, single superphosphate and muriate of potash were used to supply N, P and K, respectively. Basal of N dose was applied through ammonium sulphate at the time of planting and remaining N as top dressing from neem coated urea as per treatment. Recommended package of practices were followed for management of potato crop. Two years data were collected on per cent emergence, plant height (cm), number of shoots/plant, numbers of tubers/plant, grade wise tuber yield (0-25 g, 25-50 g, 50-75 g and >75 g), total tuber yield and per cent tuber dry matter and pooled for the statistical analysis according to the standard method [11]. The calculated values of the treatments and error variance ratio were compared with Fisher and Yates F table at 5% level of significance. The differences between significant treatments means were tested against C.D. at 5 per cent probability.

3. RESULTS AND DISCUSSION

3.1 Tuber Emergence (%)

The per cent emergence was significantly influenced by treatments in the pooled data. The significantly highest per cent tuber emergence (96%) was recorded in T_1, T_2, T_4 and which was found at par with T_5, T_6, T_7, T_8, T_3 and T_{10}. Banjare *et al.* [12] noted significantly highest plant emergence with an increase in nitrogen level up to level of 375 kg N/ha.

3.2 Plant Height

The plant height was significantly influenced by different treatments (Table 1). The significantly highest plant height (46.88 cm.) was recorded in T_{16} *i.e.* 100% RDN (275 kg N /ha) and which was at par with T_2, T_4, T_6, T_1, T_3, T_5, T_8 and T_7 which recorded 45.02, 43.13, 42.76, 42.72, 42.54, 41.05, 39.98 and 39.89 cm plant height, respectively. Pandey *et.al*. [13] also noted that at earlier stage (30 DAP), the tallest plants were measured with 50% N of RDF as basal + three foliar spray of urea @ 3% at 25, 40 & 55 DAP while at all the stages longest plants were measured in split nitrogen application as basal + topdressing + foliar.

3.3 Number of Shoots/Plant

The significantly highest number of shoots/plant (4.35) was recorded in T_2 and which was followed by T_{16}, T_1 and T_9 which recorded 3.82, 3.42 and 3.38 number of shoots/plant, respectively. Kumar *et al*. [14] also reported that the application of NPK-150:50:75 kg/ha gave significantly higher number of shoots per plant.

3.4 Number of Tubers/Plant

The pooled data of number of tubers/plant revealed that the significantly highest (10.23) number of tubers/plant was recorded in T_2 and which was statistically followed by T_{16} (8.42), T_3 (7.94) and T_5 (7.78). Similar results were also obtained by Sahu *et al.* [15]. Pandey *et al*. [13] noted the highest number of tubers with 25% N of RDF as basal + 50% top dressing at 25 DAP + one foliar spray of urea @ 3% at 40 DAP.

3.5 Grade Wise Tuber Yield (t/ha)

The significantly lowest ≤ 25 g tuber yield (0.51 t/ha) was recorded in T_{14} and which was found at par with T_{12}, T_2, T_{15}, T_1, T_{11} & T_8 which recorded 0.52, 0.54, 0.61, 0.64, 0.66 and 0.68 t/ha ≤ 25 g tuber yield, respectively. The significantly highest ≤ 25 g tuber yield (0.85 t/ha) was recorded in T_{10}. The pooled yield of >25-50 g and >50-75 g tuber yield (t/ha) were not significantly influenced by different treatments. The significantly higher >75 g tuber yield (56.97 t/ha) was recorded in T_2 and which was found at par with T_6, T_4, T_3 and T_{16} which recorded 51.72, 51.22, 50.97 and 50.57 t/ha >75 g tuber yield, respectively.

3.6 Total Tuber Yield (t/ha)

The total tuber yield was significantly influenced by different treatments. The significantly highest total tuber yield (67.81 t/ha) was recorded in T_2 and which was found at par with T_6, T_{16}, T_3, T_{10}, T_9 and T_7 which recorded 63.57, 63.22, 62.89, 61.42, 61.36 and 60.22 t/ha total tuber yield, respectively (Table 1 & Fig. 1). Our findings are supported by Kumar [16] who recorded maximum tuber yield per hectare with 50% basal N + 25% top dressing at 25 DAP + one foliar spray of urea @ 2% at 40 DAP. Das *et al.* [17] reported that maintaining an adequate supply of N in the root zone without leaching is important for optimal production of marketable quality tubers. Pandey *et al.* [13] also noted that the highest marketable tuber yield was registered with 25% N of RDF as basal + 50% top dressing at 25 DAP + one foliar spray of urea @ 3% at 40 DAP.

3.7 Per cent Tuber Dry Matter Content

The per cent tuber dry matter was not significantly influenced by treatments in the pooled data. However, the maximum tuber dry matter (18.83%) was observed with T_5.

Table 1. Potato growth and yield attributes influenced by different treatments (Pooled data of two years)

Treatment	Tuber emergence (%)	Plant height (cm)	Number of shoots/plant	No. of tubers/plant	≤ 25 g (t/ha)	>25-50 g (t/ha)	>50-75 g (t/ha)	>75 g (t/ha)	Total tuber yield (t/ha)	% tuber dry matter
T_1	96	42.72	3.42	6.72	0.64	2.33	7.58	46.21	56.77^{bcdef}	17.98
T_2	96	45.02	4.35	10.23	0.54	2.12	8.17	56.97	67.81^{a}	18.32
T_3	94	42.54	3.28	7.94	0.71	2.32	8.88	50.97	62.89^{abc}	17.60
T_4	96	43.13	2.99	6.44	0.81	1.91	5.63	51.22	59.57^{bcde}	17.58
T_5	95	41.05	3.28	7.78	0.73	2.39	8.18	47.69	58.99^{bcdef}	18.83
T_6	95	42.76	3.28	7.74	0.81	2.38	8.66	51.72	63.57^{ab}	17.28
T_7	95	39.89	3.29	7.55	0.74	2.46	7.31	49.71	60.22^{abcd}	17.77
T_8	95	39.98	3.08	5.94	0.68	2.28	10.54	40.99	54.49^{def}	17.53
T_9	93	35.22	3.38	6.99	0.69	2.17	10.47	48.02	61.36^{abcd}	17.65
T_{10}	94	35.19	2.79	6.95	0.85	2.57	9.94	48.07	61.42^{abcd}	17.42
T_{11}	93	28.83	2.51	7.75	0.66	1.87	6.80	45.89	55.22^{def}	17.15
T_{12}	93	24.48	2.96	6.79	0.52	1.95	9.75	43.30	55.53^{cdef}	17.95
T_{13}	92	24.99	2.98	7.18	0.78	2.58	10.87	38.54	52.76^{efg}	17.73
T_{14}	92	23.02	2.78	6.19	0.51	2.56	10.90	32.99	46.95^{g}	16.78
T_{15}	93	20.30	2.87	5.08	0.61	2.06	8.41	40.64	51.71^{fg}	17.42
T_{16}	93	46.88	3.82	8.42	0.72	2.44	9.50	50.57	63.22^{ab}	17.72
S.Em. ±	**0.80**	**2.91**	**0.12**	**0.29**	**0.06**	**0.39**	**1.50**	**2.51**	**2.23**	**0.45**
CD at 5 %	**2.26**	**8.76**	**0.32**	**0.92**	**0.17**	**NS**	**NS**	**7.08**	**-**	**NS**
CV %	**2.01**	**4.61**	**8.14**	**16.04**	**21.29**	**30.77**	**19.01**	**13.14**	**9.36**	**1.75**
Y × T	**NS**	**2.71**	**NS**	**NS**	**NS**	**1.14**	**2.75**	**NS**	**NS**	**0.50**

Table 2. Economics of different treatments on pooled data basis

Treatments	Tuber yield (t/ha)	Cost of cultivation (`/ha)						Selling price (₹/t)	Gross return (₹/ha)	Net Return (₹/ha)	B: C ratio
		Seed cost	Fertilizer cost	Cost of N split	Sprinkler + irrigation cost	Cultivation	Total				
T_1	56.77	120000	23216	520	18000	38500	200236	6000	340620	140384	1.70
T_2	67.81	120000	23216	1040	18000	38500	200756	6000	406860	206104	2.03
T_3	62.89	120000	23216	1560	18000	38500	201276	6000	377340	176064	1.87
T_4	59.57	120000	23216	2080	18000	38500	201796	6000	357420	155624	1.77
T_5	58.99	120000	23216	2600	18000	38500	202316	6000	353940	151624	1.75
T_6	63.57	120000	23216	520	18000	38500	200236	6000	381420	181184	1.90
T_7	60.22	120000	23216	1040	18000	38500	200756	6000	361320	160564	1.80
T_8	54.49	120000	23216	1560	18000	38500	201276	6000	326940	125664	1.62
T_9	61.36	120000	23216	2080	18000	38500	201796	6000.	368160	166364	1.82
T_{10}	61.42	120000	23216	2600	18000	38500	202316	6000	368520	166204	1.82
T_{11}	55.22	120000	23216	520	18000	38500	200236	6000	331320	131084	1.65
T_{12}	55.53	120000	23216	1040	18000	38500	200756	6000	333180	132424	1.66
T_{13}	52.76	120000	23216	1560	18000	38500	201276	6000	316560	115284	1.57
T_{14}	46.95	120000	23216	2080	18000	38500	201796	6000	281700	79904	1.40
T_{15}	51.71	120000	23216	2600	18000	38500	202316	6000	310260	107944	1.53
T_{16}	63.22	120000	25818	520	18000	38500	202838	6000	379320	176482	1.87

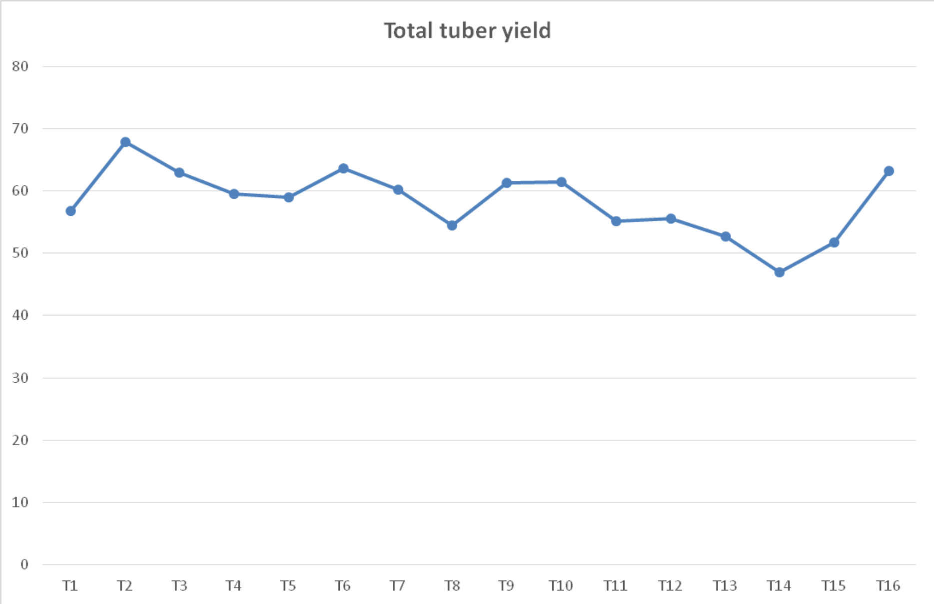

Fig.1. Influence of different treatments on total tuber yield

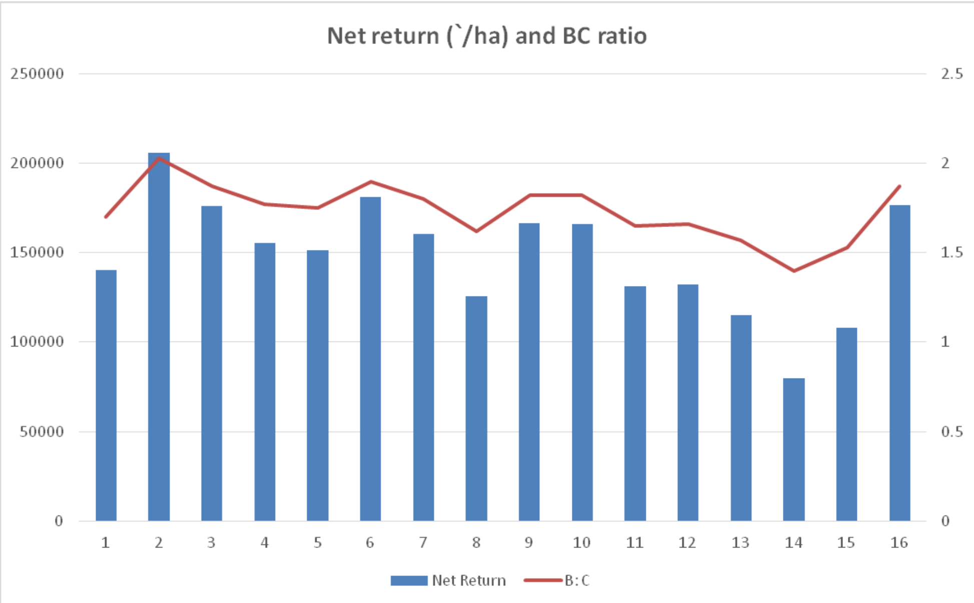

Fig. 2. Influence of different treatments on net return and BC ratio

3.8 Economics

The nitrogen application with 50 % basal + 50 % split and two split (30 and 45 DAP) gave the highest net returns (206104) and BC ratio (2.03) which was followed by application of nitrogen with 25 % basal + 75 % split and one split (30 DAP) which recorded 1.90 BC ratio (Table 2 & Fig. 2). Bera *et al*. [18] also noted the highest net return and benefit cost ratio with application of both N and K applied in three splits (1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP). Singh *et al.* [19] also reported that the balance use of nutrients could be the most accepted treatment to obtain maximum benefit from the potato.

4. CONCLUSION

The potato growers of North Gujarat agro-climatic zone-IV growing potato under sprinkler irrigation system are recommended to apply 206 kg N/ha. Out of this, 50 % N (103 kg) as basal and remaining 50 % N (103 kg) in two equal splits at 30 and 45 DAP along with 110 : 275 kg P_2O_5 : K_2O/ha as basal application for obtaining higher tuber yield and net return with saving of 25 % Nitrogen.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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