EFFECT OF INTEGRATED NITROGEN MANAGEMENT ON YIELD AND QUALITY OF POTATO (*Solanum tuberosum* L.)

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ABSTRACT

A field experiment was conducted during 2010-11 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat to study the integrated nitrogen management in potato (Solanum tuberosum L.) in sandy loam type of soil, low in organic carbon content and available nitrogen, medium in available phosphorus, high in potash with 7.2 pH. The experiment was conducted with ten treatments comprising of RDN (NPK @ 200-100-220 kg ha^{-1}) along with different combinations of fertilizers with various sources of organic manures viz; farm yard manure (FYM) and vermicompost (VC) under randomized block design with four replications. Results showed that maximum number of shoots per meter row length (22.36), dry matter accumulation (46.00 g), number of tubers per plant (8.10), tuber yield per plant (482.63 g), tuber yield (27.25 t/ha), haulm yield (15.75 t/ha), grade wise tuber yield ('A' grade 15.26 t/ha), starch content (48.00 %) and available nitrogen in soil (268.50 kg/ha) at harvest was recorded when out of 100 % RDN (200 kg N/ha), 75 % RDN was applied through fertilizer and 25% RDN was applied through organic manure (50 % FYM + 50 % VC) to potato var. Kufri Pukhraj. Maximum gross (Rs.228420 per ha) and net (Rs. 137459 per ha), net realization as well as BCR (1:2.51) was also obtained in the same treatment.

KEY WORDS: Integrated nitrogen management, potato

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a highly nutritious food and has a good quality protein. It is considered as one of the four major food crops of the world; the others being rice, wheat and maize. Potato contains very small quantity of fat, large number of minerals and good quality dietary fibres which are superior to wheat bran (Shekhawat, 2001). Potato is a high yielding short duration crop and can be grown with higher economic returns under any climate, provided the night temperature during tuberization remains around 20^{o}C (Shekhawat and Naik, 1999).

Presently, India ranks third in production and fourth in area in the world (Naik, 2005). The area under potato crop was 20.85 lakh hectares hectares with a production of 480.95 lakh million tonnes with a productivity of 23.07 t/ha during 2015-16 (Anonymous, 2016a). The crop has got immense potentiality for cultivation in Gujarat. The major potato growing districts in Gujarat are Banaskantha, Kheda, Anand, Mehsana, Ahmedabad and Sabarkantha. Gujarat Ranks fourth in terms of production in the country (Anonymous, 2016). In Gijarat, during 2012-13, potato was grown in an area of 81270 hectares with a production of 24997.30 million tonnes and yield of 30758 kg/ha (Anonymous, 2016b).

Having a sparse root system and highest dry matter production per unit time, nutrient needs of potato is higher than cereals.

Supply of nutrients plays an important role in growth and yield of potato. Nitrogen being an essential constituent of protein and chlorophyll, contributes a lot in potato production. Nitrogen increases the leaf area, which increases the amount of solar radiation intercepted and consequently, increases days to flowering, days to physiological maturity, plant height and dry matter production of different plant parts (Krishnippa, 1989). Therefore, balance nitrogen fertilization is very important in potato production. It is now being increasingly realized that the concept of integrated nitrogen management, taking into account for soil fertility as determined by soil and plant tests, judicious use of fertilizers by selecting proper source, time and method of application, integrated use of organic manures and inorganic fertilizers etc. which helps in sustaining crop productivity without much affecting soil ecosystem. Application of organic manures has shown considerable increase in crops yield, but its alone use does not meet the requirement of nutrients for increasing the yield of potato. Therefore, integration of organic and inorganic sources in appropriate proportion assumes special implications due to complementary impact to each other in crop production.

It is evident from the literature that a little work has been carried out to study the integrated effect of organic and inorganic sources of nitrogenous fertilizer on yield and quality of potato in Gujarat. Therefore, it is necessary to find out the suitable combination of organic and inorganic sources of nitrogen which may be helpful in increasing the yield and improve the quality of potato tubers. Keeping the above views, present investigation has been made to study the integrated nitrogen management in potato (*Solanum tuberosum* L.).

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2010-11 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The soil of experimental area was sandy loam in texture, low in organic content (0.32%) and available nitrogen (192.6 kg N/ha), medium in available phosphorus (34.50 kg P_2O_5/ha), and high in potash (398.40 kg K_2O /ha) with 7.2 pH. There were all together ten treatments comprising of T_1 (100 % RDN), T_2 [75% RDN + 25% OM (25% FYM + 75% VC)], T_3 [75% RDN + 25% OM (50% FYM + 50% VC)], T_4 [75% RDN + 25% OM (75% FYM + 25% VC)], T_5 [50% RDN + 50% OM (25% FYM + 75% VC)], T_6 [50% RDN + 50% OM (50% FYM + 50% VC)], T_7 [50% RDN + 50% OM (75% FYM + 25% VC)], T_8 [25% RDN + 75% OM (25% FYM + 75% VC)], T_9 [25% RDN + 75% OM (50% FYM + 50% VC)] and T_{10} [25% RDN + 75% OM (75% FYM + 25% VC)] were taken in the experiment and tested under Randomized Block Design with four replications (Table 1). The recommended dose of fertilizer was NPK @ 200-100-220 kg/ha, wherein full dose of phosphorus i.e. 100 kg P_2O_5 /haand potash i.e. 220 kg K_2O/ha, whereas half dose of nitrogen as per treatment were applied as a basal dose in furrows planting in the form of diammonium phosphate, sulphate of potash and urea fertilizers. The remaining half dose of nitrogen was applied as top dressing in the form of urea after 30 DAP as per treatment. Potato tubers of variety Kufri Pukhraj were treated with Mancozeb @ 1 kg/ha as seed treatment, followed by blending with boric powder @ 5 kg/ton of potato seed before planting. Potato tubers were cut in pieces, keeping two to three eye buds with approximately 25 to 40 g weight and then it was planted in pre-irrigated plot at 45 cm inter and 20 cm intra row spacing at the depth of 4.5 cm on the flat bed using seed rate of 25 q/ha. Post planting irrigation was given 21 DAP, followed by six irrigations at 7-8 days interval. Earthing up was done 40 DAP. The data were recorded different growth parameters, tube yield, haulm yield and other yield attribtes as well as available nitrogen and organic carbon content in the soil after harvest of potato. Economics was also calculated.

RESULTS AND DISCUSSION

Effect on growth parameters

Results shown in Table 2 indicated significant influence of different sources on number of shoots per meter row length and plant height at different growth stage of potato. Significantly higher number of shoots per meter row length were obtained under treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)] at 30 DAP (20.33) and at harvest (22.36). However, it was found at par with T_4 at 30 DAP and T_4 and T_2 at harvest. Nevertheless, the minimum number of shoots per meter row length (14.92 and 17.46 at 30 DAP and harvest, respectively) were recorded in treatment T_{10} [25% RDN + 75% OM (75% FYM + 25% VC)]. Significantly the maximum plant height was recorded in treatment T_1 (100% RDN) i.e. 27.59, 38.50 and 48.00 cm at 30 DAP, 60 DAP and at harvest, respectively, while the shortest plant heights of 20.46, 29.98 and 38.30 cm at 30 DAP, 60 DAP and at harvest, respectively were obtained in treatment T_{10} [25% RDN + 75% OM (75% FYM + 25% VC)]. This could be due to sufficient quantity of nitrogen availability in readily accessible ionic form at initial stage which might have been obtainable for uptake by the plant, resulted in to positive source to sink ratio, followed by subsequent transition of nitrogen towards increasing number of shoots at initial stage. Contrary to this, 25% RDN might cause a temporary shortage of available nitrogen which initially had been required for cell elongation by the plant might be resulted into poor number of shoots per meter row length and plant height in treatment T_{10}. This preliminary deficiency might have relentless consequences up to harvest. These results were in conformity with the findings of Krishnamurthy *et al.* (2002), Banafar *et al.* (2005) and Zelalem *et al.* (2009) in potato.

Effect on yield attributes and yield

Significant differences had been observed (Table 3) due to application of various combinations of organic and inorganic nitrogenous fertilizers in respect of dry matter accumulation per plant, number of tubers per plant, tuber yield per plant, tuber and haulm yield t/ha. The results revealed that treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)], being at par with T_4 at 30 DAP, with treatment T_4 and T_5 at 60 DAP recorded appreciably higher dry matter accumulation at 30 DAP (24.33 g), 60 DAP (33.05 g) and at harvest (46.00 g), respectively, whereas the lowest dry matter accumulation of 17.18, 24.78 and 35.25 g at 30 DAP, 60 DAP and at harvest, respectively, had been reported under treatment T_{10}. Similar trend was observed for number of tubers per plant and tuber yield (t/ha), wherein treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)], being at par with T_4 produced significantly higher number of tubers per plant (8.10) and tuber yield (27.25 t/ha), which was found 20.3 per cent higher compared to the lowest tuber yield (21.71 t/ha) received in treatment T_{10}. However, treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)] produced significantly the highest tuber yield per plant (482.63 g) and haulm yield (15.75 t/ha) over rest of the treatment combinations. High nitrogen fertilization might have enhanced growth activity of tubers, which might have increased the demand that favoured greater movement of the substrates to the storage organs (Das Gupta, 1972). An increase in tuber yield with the combined treatments was mainly due to increased size of tuber which might be the result of enhanced growth throughout the growing period leading to more efficient translocation of photosynthates to tubers and thereby boosting tuber size and hence increases in dry matter accumulation of plants as well as tubers. These results are in conformity with the findings of Upadhayay *et al.* (2003), Kushwah *et al.* (2005), Singh and Singh (2005) and Banafar *et al.* (2005) in potato.

Effect on quality of potato

Quality parameters *viz*., grading and starch content had been significantly influenced due to various treatment combinations (Table 4). It was observed from the data that all the treatments of integrated nitrogen management were found significantly differed among each other for

different grades. Treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)] recorded highest yield for grade A (15.26 t/ha), with 56% of tubers with superior quality. It was also further revealed that the lowest yield of C grade tubers (1.64 t/ha); contributing only 6.0 % share in total tuber production, was also obtained in treatment T_3, pointing the importance of early supplementation of sufficient quantity of nitrogen that could be easily uptake by the plants. For grade 'B', the maximum tuber yield (12.68 t/ha) was recorded in treatment T_7 [50% RDN + 50% OM (75% FYM + 25% VC)] with 52% share, indicating influence of inorganic source during preliminary growth stage. The highest yield with grade C (3.51 t/ha) was observed in treatment T_5 [50% RDN + 50% OM (25% FYM + 75% VC)]. Results pointed out that treatment receiving 75% N in the form of inorganic fertilizer and 25% N in the form of organic matter produced more superior grade tubers, indicating that adequate accessibility of nitrogen in the available form at initial stage had positive correlation with initial vigorous growth resulted into higher growth parameters, more efficient translocation of photosynthates to tubers and thereby enlarging tuber size escalating dry matter accumulation of plants as well as tubers. Deka and Dutta (1997) and Faten *et al.* (2008) also confirmed the results.The perusal of data further revealed that considerably the highest percentage of starch content (48.00%) was observed in treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)]. This could be accredited to increase in synthesis of more carbohydrates due to combined application of nutrients and their accumulation in tubers. Similar results were reported by Singh *et al.* (1998) and Hassandokht and Kashi (2000).

Effect on soil nitrogen status

The perusal of data pertaining to nitrogen and organic carbon content in soil after harvest of potato (Table 5) revealed that significantly the highest N content in soil after harvest (268.50 kg/ha) was observed in treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)]**,** whereas the highest organic carbon content (0.49 %) was observed under the treatment T_8 [25% RDN + 75% OM (25% FYM + 75% VC)]. This might be due to influence of organic manures on availability of nutrients in combination with inorganic fertilizers by enhancing biochemical activities through improving soil physical properties and thereby raising concentration of nitrogen and organic carbon in soil after harvest (Patil *et al.*,1997).

Economics

The mean data on cost of cultivation incurred with gross realization and BCR of potato as affected by integration of organic and inorganic sources of nitrogenous fertilizer presented in Table 6 revealed that highest net realization of Rs. 137459 per ha and BCR of 1:2.51 was obtained in treatment T_3 [75% RDN + 25% OM (50% FYM + 50% VC)] and it was followed by treatment T_4 with net realization of Rs. 130513 per ha and BCR of 1:2.45. The lowest net realization of Rs. 73064 per ha and BCR of 1:1.71 was received under treatment T_{10}. Similar findings were reported by Patel *et al*. (2006).

CONCLUSION

It could be concluded that for securing higher tuber yield, good quality of tubers along with higher remuneration for potato crop (var. Kufri Pukhraj), out of 100% RDN (200 kg N/ha), 75% of recommended dose of nitrogen should be applied through inorganic sources (fertilizer) and remaining 25% recommended dose of nitrogen should be applied through organic sources comprising of 50% FYM and 50% Vermicompost on loamy sand soil under middle Gujarat conditions.

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Table 1: Details of treatments

Sr No.	Details of Treatments
T_1	100 % RDN
T_2	75% RDN +
T_3	75% RDN +
T_4	75% RDN +
T_5	50% RDN +
T_6	50% RDN +
T_7	50% RDN +
T_8	25% RDN +
T_9	25% RDN +
T_{10}	25% RDN +

Where,
RDN = Recommended Dose of Nitrogen
OM = Organic Matter
FYM = Farm Yard Manure
VC = Vermicompost

Table 2: Effect of different INM treatments on growth parameters of potato

Sr. No.	Treatments	Number of Shoots per Meter Row Length		Plant Height (cm)		
		At 30 DAP	At Harvest	At 30 DAP	At 60 DAP	At Harvest
T_1	100 % RDN	15.50	17.52	27.59	38.50	48.00
T_2	75% RDN + 25%OM	17.65	19.70	24.35	34.30	42.25
T_3	75% RDN + 25%OM	20.33	22.36	24.92	35.00	45.50
T_4	75% RDN + 25%OM	19.75	21.89	26.81	35.60	44.55
T_5	50% RDN + 50%OM	16.25	18.04	22.85	32.83	40.88
T_6	50% RDN + 50%OM	16.83	18.87	23.65	33.50	41.50
T_7	50% RDN + 50%OM	16.88	19.17	24.12	33.90	41.88
T_8	25% RDN + 75%OM	16.81	18.89	23.78	33.68	41.65
T_9	25% RDN + 75%OM	16.38	18.47	23.41	33.15	41.23
T_{10}	25% RDN + 75%OM	14.92	17.46	20.46	29.98	38.30
S.Em (±)		0.89	0.94	0.98	1.08	1.16
CD at 5%		2.58	2.73	2.84	3.12	3.37
CV %		10.39	9.8	8.03	6.28	6.44

Table 3: Effect of different INM treatments on yield attributes and yield of potato

Sr. No.	Treatments	Dry Matter Accumulation per Plant (g)			Number of Tubers per Plant	Tubers Yield per Plant (g)	Tuber Yield (t/ha)	Haulm Yield (t/ha)
		At 30 DAP	At 60 DAP	At Harvest				
T_1	100 % RDN	20.08	28.28	39.00	6.40	242.63	22.78	11.28
T_2	75% RDN + 25%OM (25%FYM+75%VC)	21.33	30.25	40.28	6.56	251.25	24.57	11.98
T_3	75% RDN + 25%OM (50%FYM+50%VC)	24.33	33.05	46.00	8.10	482.63	27.25	15.75
T_4	75% RDN + 25%OM (75%FYM+25%VC)	23.50	32.50	42.50	7.75	377.50	26.51	14.08
T_5	50% RDN + 50%OM (25%FYM+75%VC)	19.85	28.83	38.85	6.38	240.00	23.38	11.40
T_6	50% RDN + 50%OM (50%FYM+50%VC)	20.53	29.50	39.50	6.45	180.00	24.03	12.25
T_7	50% RDN + 50%OM (75%FYM+25%VC)	20.95	29.86	39.90	6.47	297.50	24.38	12.00
T_8	25% RDN + 75%OM (25%FYM+75%VC)	20.90	30.00	39.63	6.45	198.50	23.78	12.85
T_9	25% RDN + 75%OM (50%FYM+50%VC)	20.05	29.00	39.59	6.46	191.25	23.83	12.88
T_{10}	25% RDN + 75%OM (75%FYM+25%VC)	17.18	24.78	35.25	6.08	171.25	21.71	10.38
S. Em (±)		0.97	1.02	1.09	0.13	12.54	0.60	0.60
CD at 5%		2.81	2.96	3.16	0.36	36.39	1.75	1.04
CV %		9.18	6.82	6.39	8.50	9.53	8.32	10.46

Table 4: Effect of different INM treatments on quality of potato

Sr. No.	Treatments	Grade Wise Tuber Yield (t ha^{-1})			Starch Content (%)
		A (>75g)	B (25-75g)	C (<25g)	
T_1	100 % RDN	9.58* (42.0)	10.93 (48.0)	2.28 (10.0)	38.03
T_2	75% RDN + 25%OM (25%FYM+75%VC)	10.81 (44.0)	10.57 (43.0)	3.19 (13.0)	42.25
T_3	75% RDN + 25%OM (50%FYM+50%VC)	15.26 (56.0)	10.36 (38.0)	1.64 (6.0)	48.00
T_4	75% RDN + 25%OM (75%FYM+25%VC)	14.05 (53.0)	10.61 (40.0)	1.86 (7.0)	42.55
T_5	50% RDN + 50%OM (25%FYM+75%VC)	9.59 (41.0)	10.29 (44.0)	3.51 (15.0)	40.88
T_6	50% RDN + 50%OM (50%FYM+50%VC)	9.61 (40.0)	11.77 (49.0)	2.64 (11.0)	41.50
T_7	50% RDN + 50%OM (75%FYM+25%VC)	9.02 (37.0)	12.68 (52.0)	2.68 (11.0)	41.88
T_8	25% RDN + 75%OM (25%FYM+75%VC)	10.70 (45.0)	10.94 (46.0)	2.14 (9.0)	42.00
T_9	25% RDN + 75%OM (50%FYM+50%VC)	9.29 (39.0)	12.63 (53.0)	1.91 (8.0)	43.25
T_{10}	25% RDN + 75%OM (75%FYM+25%VC)	8.25 (38.0)	11.72 (54.0)	1.72 (8.0)	43.00
S. Em (±)		0.39	0.29	0.06	1.10
CD at 5%		1.14	0.85	0.17	3.18
CV %		7.41	5.22	5.05	5.14

Data in parenthesis shows grade wise percentage of total tuber yield

Table 5: Effect of different INM treatments on Nutrient content in soil at harvest in potato

Sr. No.	Treatments	Available Nitrogen (kg/ha)	Organic Carbon (%)
T_1	100 % RDN	240.50	0.27
T_2	75% RDN + 25%OM (25%FYM+75%VC)	245.00	0.32
T_3	75% RDN + 25%OM (50%FYM+50%VC)	268.50	0.33
T_4	75% RDN + 25%OM (75%FYM+25%VC)	255.25	0.33
T_5	50% RDN + 50%OM (25%FYM+75%VC)	242.00	0.36
T_6	50% RDN + 50%OM (50%FYM+50%VC)	242.88	0.38
T_7	50% RDN + 50%OM (75%FYM+25%VC)	243.75	0.35
T_8	25% RDN + 75%OM (25%FYM+75%VC)	243.25	0.49
T_9	25% RDN + 75%OM (50%FYM+50%VC)	236.50	0.47
T_{10}	25% RDN + 75%OM (75%FYM+25%VC)	219.00	0.48
S. Em (±)		7.29	0.02
CD at 5%		22.46	0.07
CV %		6.35	12.90

Table 6: Economics of potato as influenced by different INM treatment combinations

Treatment	Tuber Yield (t/ha)				Gross Realization (Rs. per Ha)				Total Cost of Cultivation (Rs. per Ha)	Net Realization (Rs. per Ha)	BCR
	A	B	C	Total	A	B	C	Total			
T_1	9.58	10.93	2.28	22.78	86220	87440	11400	185060	83400	101660	1 : 2.22
T_2	10.81	10.57	3.19	24.57	97290	84560	15950	197800	92225	105575	1 : 2.14
T_3	15.26	10.36	1.64	27.25	137340	82880	8200	228420	90961	137459	1 : 2.51
T_4	14.05	10.61	1.86	26.51	126450	84880	9300	220630	90117	130513	1 : 2.45
T_5	9.59	10.29	3.51	23.38	86310	82320	17550	186180	101051	85129	1 : 1.84
T_6	9.61	11.77	2.64	24.03	86490	94160	13200	193850	98941	94909	1 : 1.96
T_7	9.02	12.68	2.68	24.38	81180	101440	13400	196020	96620	99400	1 : 2.03
T_8	10.70	10.94	2.14	23.78	96300	87520	10700	194520	109876	84644	1 : 1.77
T_9	9.29	12.63	1.91	23.83	83610	101040	9550	194200	106711	87489	1 : 1.82
T_{10}	8.25	11.72	1.72	21.71	74250	93760	8600	176610	103546	73064	1 : 1.71

Selling price: ***A grade tuber @ 9 Rs. per kg***
B grade tuber @ 8 Rs. per kg
C grade tuber @ 5 Rs. per kg

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