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Source and Method of nitrogen application effect on *Rabi* baby corn (*Zea mays* L.) under drip system

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Abstract
A field experiment was conducted to study the response of source and method of nitrogen application on *Rabi* baby corn (*Zea mays* L.) under drip system during 2015-16 at Tribal Research cum Training Centre, Anand Agricultural University, Devgadhbaria, Dist.- Dahod. Eight treatment combinations comprising of two method of application {(M_1:- drip nitrogen fertigation and M_2:- Traditional base application (soil application)} and four nitrogen sources (F_1:- Urea, F_2:- Urea Phosphate, F_3:- Calcium Nitrate and F_4: Ammonium Sulphate) were tried under split plot design with four replications. Treatment drip nitrogen fertigation recorded significantly highest growth components *viz*, plant height at 30 DAS and first picking, number of leaves at first picking, dry matter accumulation at 30 DAS and first picking, crop growth rate 0-30 DAS and 30-58 DAS and maximum value of yield components *viz*., length of husked and dehusked baby corn, girth of dehusked baby corn, weight of husked and dehusked baby corn per plant, husked and dehusked baby corn yield, green fodder yield and stalk yield of baby corn. Treatment F_4 (Ammonium sulphate) recorded significantly higher growth components *viz*., plant height at 30 DAS and first picking, number of leaves at first picking, dry matter accumulation at 30 DAS and first picking, crop growth rate 0-30 DAS and 30-58 DAS and maximum value of yield components *viz*., length of husked and dehusked baby corn, girth of dehusked baby corn, weight of husked and dehusked baby corn per plant, husked and dehusked baby corn yield, green fodder yield and stalk yield of baby corn. The treatment drip nitrogen fertigation of ammonium sulphate gave significantly higher length of husked and dehusked baby corn. The treatment drip nitrogen fertigation of ammonium sulphate recorded 42.59 per cent and 42.56 per cent significantly the husked and dehusked baby corn yield, respectively as compared to traditional application of calcium nitrate. The drip nitrogen fertigation of ammonium sulphate gave maximum value of gross realization and net realization as compared to other treatment. Drip nitrogen fertigation of ammonium sulphate and drip nitrogen fertigation of urea gave maximum value of BCR as compared other treatment.

Keywords: nitrogen application effect, *Zea mays* L, drip system, Ammonium sulphate

Introduction
Maize (*Zea mays* L.) is one of the most important cereal in the world's agriculture economy both as food for human being and feed and fodder for cattle. There is no any other cereal on the earth, which has so immense potential as to maize and hence occupied a place as "Queen of cereals". Baby corn is the ear of maize plant harvested in young stage especially when the silk have either emerged or just emerging. The term "baby corn" is commonly used by food industry. Baby corn can be a promising cash crop due to good market potential as the habit of diet in the urban area is changing day by day. It can be fitted in rice and maize based cropping system, as it is a short duration crop, maturing in 60 to 65 days. It contains 86 mg phosphorus, 28 mg calcium, 8.2 g carbohydrates, 10.04 g protein, 0.20 g fat and 0.10 mg iron per 100 g of edible portion (Thakur, 2000) [17]. Its byproducts, such as tassel, young husk silk and green stalk provide good cattle feed. Proper method of nitrogen application and proper source of nitrogen is one of the best measures for increase nitrogen use efficiency and decrease its losses. Applying fertilizer through the irrigation system has several advantages like, nutrient can be applied at any time during the season and according to plant requirements, placement of mobile nutrients such as nitrogen can be regulated in the soil profile by the amount of water applied, applied nutrients are readily available for rapid plant uptake, nutrients are applied uniformly over the field and crop damage during fertilizer application is minimized (FAO, 2005) [7]. It is most important to decide proper source of nitrogen and method of application gave higher yield and net realization.

Material and methods
An experiment was conducted at Tribal Research cum Training Centre, Anand Agricultural University, Devgadhbaria, Dist.- Dahod, Gujarat during 2015-16.

The texture of soil is loamy sand having pH=7.4, EC=0.13 dS m^{-1}, organic carbon=0.33 per cent, available nitrogen=219.52 kg ha^{-1}, available Phosphorus=47.16 kg ha^{-1} and available potassium=286.27 kg ha^{-1}. VL Baby Corn 1 (VL-78) was used for experiment. The treatment consists of two method of nitrogen application i.e. Drip nitrogen fertigation and Traditional base application (soil application) and four nitrogen sources i.e. Urea, Urea Phosphate, Calcium Nitrate and Ammonium Sulphate. Thus eight treatment combinations were replicated four times in split plot design. First irrigation at sowing the seed and given drip irrigation after at 4 DAS. Drip irrigation treatments were given at an alternate days based on fraction of pan evaporation of two days. Daily pan evaporation measured with the help of open pan evaporimeter installed in meteorological observatory. 0.8 PET (Alternate day) means fraction of two days pan evaporation calculation given drip irrigation. The crop was fertilized as per recommended dose (120-60-00 NPK kg ha^{-1}). Among which 60 kg P_2O_5 were applied as basal dose in all treatment in the form of single super phosphate (SSP) except urea phosphate. Additional sulphur in the form of granular sulphur was added in the treatment of urea phosphate to nullify the effect of sulphur of single super phosphate. Remaining nitrogen in the treatment urea phosphate was applied in the form of urea. 120 kg N were applied by different nitrogenous fertilizers (as per treatments) in four equal split (basal, 20, 30, 40 DAS). The randomly selected plants were tagged and used for recording various observations on growth and yield parameters.

Result and discussion

Effect of nitrogen application

Result revealed that drip nitrogen fertigation (M_1) had significantly tallest plants at 30 DAS (74.40 cm) and at first picking (137.29 cm). It might be due to placement of mobile nutrient such as nitrogen can be regulated in soil profile as well as root zone area by the amount of water. Applied nutrients are readily available for rapid uptake which increases the nutrient use efficiency. This is responsible for increasing the height. The present findings are in close agreement with those reported by Alcantara (2015) [2] and Zhou *et al*. (2017) [19]. Drip nitrogen fertigation (M_1) recorded significantly highest dry matter accumulation at 30 DAS (16.52 g $plant^{-1}$) and at first picking (60.80 g $plant^{-1}$). It was due to increase in plant height, numbers of leaves and husked cob weight directly reflected in dry matter accumulation. These findings are in accordance with those reported by Kakade *et al*. (2015) [11] and Zhou *et al.* (2017) [19]. Crop growth rate at 0-30 DAS (0.55 g day^{-1}) and 30-58 DAS (1.58 g day^{-1}) significantly highest recorded under treatment drip nitrogen fertigation (M_1) as compared to traditional application (M_2). Drip nitrogen fertigation (M_1) recorded significantly highest length of husked (19.56 cm) and dehusked (9.64 cm) baby corn, girth of dehusked baby corn (3.64 cm) and husked (78.18 g) and dehusked (17.55 g) cob weight per plant. It was due to significantly increase in cob girth and length which directly reflected in weight of husked and dehusked cob per plant. The treatment drip nitrogen fertigation (M_1) recorded 17.85 per cent significantly highest husked baby corn yield (73.00 q ha^{-1}) as compared to tradition application (M_2). Drip nitrogen fertigation (M_1) significantly highest dehusked baby corn and green fodder yield as compared to traditional base application (M_2). The treatment of drip nitrogen fertigation (M_1) recorded 22.58 per cent significantly the highest stalk yield (62.21 kg ha^{-1}) as compared to traditional base application (M_2). The results are substantiated with Ganesaraja *et al*. (2009) [8], Patil *et al*. (2011) [13], Gupta *et al*. (2014) [9] and Ojagh *et al*. (2015) [12].

Effect of nitrogen sources

Application of ammonium sulphate (F_4) significantly higher plant height at 30 DAS (74.21 cm) and first picking (135.36 cm), number of leaves per plant at first picking (13.04) and dry matter accumulation at 30 DAS (15.76 g $plant^{-1}$) and first picking (58.75 g $plant^{-1}$) but it was remained at par with application of urea (F_1). It might be due to ammonium sulphate has been superior to other nitrogen sources due to losses by volatilization, leaching and denitrification. In addition to that ammonium sulphate contains nitrogen as well as free sulphur and had many potential agronomic and environment benefits over sources. Similar results were also reported by Ayub *et al*. (2000) [5], Rabska and Sowinski (2014) [14], Safdarian *et al*. (2014) [15] and Ali *et al*. (2015) [3]. CGR was found significantly higher under treatment ammonium sulphate (F_4) and it was at par with application of urea (F_1) and urea phosphate (F_2). Length of husked (19.39 cm) and dehusked (9.48 cm) baby corn and girth of dehusked baby corn (3.58 cm) were significantly higher under application of ammonium sulphate (F_4) which was remained at par with the application of urea (F_1). This might be due to combined application of nitrogen and sulphur show positive effect on increasing the cob length and girth due to nitrogen and sulphur fertilization results in greater translocation of photosynthesis from vegetative part to developing baby corn. The results are substantiated with Biswas and Ma (2016) [6]. Significantly higher weight of husked (74.75 g) and dehusked (16.78 g) baby corn per plant, husked (71.39 q ha^{-1}) and dehusked (16.03 q ha^{-1}) baby corn yield and green fodder (271.28 q ha^{-1}) and stalk yield (61.51 q ha^{-1}) were recorded under application of ammonium sulphate (F_4) which was statically at par with application of urea (F_1) and urea phosphate (F_2). It was due to significant increase in cob girth and length which directly reflected in weight of husked and dehusked cob per plant and yield per hectare. The results showed that ammonium sulphate (F_4) recorded 14.17 and 21.86 per cent significantly the higher dehusked baby corn yield (16.03 q ha^{-1}) and green fodder yield (271.28 q ha^{-1}), respectively as compared to calcium nitrate (F_3). These findings are in accordance with those reported by Spratt and Gasser (1970) [16], Abbasi *et al*. (2013) [1], Safdarian *et al.* (2014) [15] and Amanullah *et al*. (2016).

Interaction effect

Application of ammonium sulphate by drip fertigation (M_1F_4) significantly higher length of husked (21.58 cm) and dehusked corn (10.25 cm) which was at par with application of urea by drip fertigation (M_1F_1). This might be due to ammonium sulphate fertilizer containing nitrogen and sulphur elements applied with drip fertigation is rapidly available at root zone with is responsible for increase in fertilizer use efficiency which is responsible for high length of husked and dehusked baby corn. Application of ammonium sulphate by drip fertigation (M_1F_4) recorded significantly highest weight of husked (84.77 g) and dehusked (19.03 g) baby corn per plant as compared to other treatments. The treatment ammonium sulphate by drip fertigation (M_1F_4) recorded 42.59 per cent and 42.56 per cent significantly the husked (79.92 q ha^{-1}) and dehusked (17.95 q ha^{-1}) baby corn yield as compared to traditional application of calcium nitrate (M_2F_3). It was due to increasing length of husked and dehusked baby corn, weight of husked and dehusked baby corn per plant which is directly reflected in total husked and dehusked baby corn yield per hector. This was confirmation of the results obtained by Haynes and Swift (1987) [10] and Vargas (2015) [18]. Treatment combination drip nitrogen fertigation with ammonium sulphate (M_1F_4) registered the higher net realization (151403 ha^{-1}) and gross realization (189415 ha-1) while drip nitrogen fertigation with urea (M_1F_4) have maximum BCR value 5.4.

Table 1: Growth attribute of baby corn as influenced by method of nitrogen application and nitrogen sources

Treatment	**Plant height (cm)**			**Number of leaves plant^{-1}**		**Dry matter accumulation (g plant^{-1})**		**Crop Growth Rate (g day^{-1})**	
	15 DAS	**30 DAS**	**1st picking**	**30 DAS**	**1st picking**	**30 DAS**	**1st picking**	**0-30 DAS**	**30-58 DAS**
Method of Nitrogen application (M)									
M_1 : Drip nitrogen fertigation	26.29	74.40	137.29	8.25	13.49	16.52	60.80	0.55	1.58
M_2 : Traditional base application (soil)	25.29	63.33	124.36	7.57	11.43	12.30	49.92	0.41	1.34
S. Em. ±	0.75	2.00	2.83	0.22	0.34	0.43	1.63	0.02	0.05
CD (P=0.05)	NS	8.99	12.73	NS	1.53	1.92	7.32	0.07	0.21
C.V. %	11.55	11.62	8.65	11.35	10.90	11.85	11.75	12.39	12.74
Nitrogen sources (F)									
F_1 : Urea	26.13	69.78	133.13	7.84	12.38	14.66	56.80	0.49	1.50
F_2 : Urea Phosphate	25.53	67.61	128.90	7.86	12.38	13.97	54.02	0.47	1.43
F_3 : Calcium Nitrate	25.16	63.86	125.90	7.66	12.02	13.26	51.87	0.44	1.38
F_4 : Ammonium Sulphate	26.35	74.21	135.36	8.29	13.04	15.76	58.75	0.53	1.53
S. Em. ±	0.87	1.77	2.38	0.25	0.24	0.44	1.19	0.02	0.04
CD (P=0.05)	NS	5.27	7.08	NS	0.71	1.31	3.54	0.04	0.12
Interaction (M X F)	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	9.52	7.28	5.15	8.78	5.43	8.63	6.09	8.56	7.54

Table 2: Yield attribute of Baby Corn as influenced by method of nitrogen application and nitrogen sources

Treatment	**Length of husked baby corn (cm)**	**Length of dehusked baby corn (cm)**	**Cob girth of dehusked baby corn (cm)**	**Weight of husked corn plant^{-1} (g)**	**Weight of dehusked corn plant^{-1} (g)**
Method of Nitrogen application (M)					
M_1 : Drip nitrogen fertigation	19.56	9.64	3.64	78.18	17.55
M_2 : Traditional base application (soil)	16.64	8.52	3.21	62.75	14.09
S. Em. ±	0.40	0.20	0.07	2.21	0.47
CD (P=0.05)	1.80	0.90	0.33	9.96	2.10
C.V. %	8.83	8.83	8.60	12.56	11.78
Nitrogen sources (F)					
F_1 : Urea	18.67	9.28	3.48	72.43	16.26
F_2 : Urea Phosphate	17.53	8.85	3.36	70.62	15.85
F_3 : Calcium Nitrate	16.82	8.72	3.29	64.07	14.38
F_4 : Ammonium Sulphate	19.39	9.48	3.58	74.75	16.78
S. Em. ±	0.35	0.19	0.07	1.66	0.38
CD (P=0.05)	1.04	0.57	0.21	4.95	1.13
Interaction (M X F)	Sig.	Sig.	NS	Sig.	Sig.
C.V.%	5.47	5.93	5.80	6.68	6.82

Table 3: Baby corn yield, green fodder yield, stalk yield and harvest index as influenced by method of nitrogen application and nitrogen sources.

Treatment	**Husked baby corn yield (q ha^{-1})**	**Dehusked baby corn yield (q ha^{-1})**	**Green fodder yield (q ha^{-1})**	**Stalk yield (q ha^{-1})**	**Harvest index (%)**
Method of Nitrogen application (M)					
M_1 : Drip nitrogen fertigation	73.00	16.39	274.03	62.21	21.01
M_2 : Traditional base application (soil)	61.94	13.91	223.47	50.75	21.72
S. Em. ±	2.19	0.44	8.44	1.78	0.67
CD (P=0.05)	9.84	1.97	37.97	8.00	NS
C.V. %	12.96	11.54	13.57	12.58	12.59
Nitrogen sources (F)					
F_1 : Urea	68.64	15.41	253.44	57.59	21.43
F_2 : Urea Phosphate	67.31	15.11	247.67	56.32	21.39
F_3 : Calcium Nitrate	62.55	14.04	222.60	50.52	21.94
F_4 : Ammonium Sulphate	71.39	16.03	271.28	61.51	20.70
S. Em. ±	1.40	0.31	8.16	1.82	0.70
CD (P=0.05)	4.15	0.93	24.25	5.42	NS
Interaction (M X F)	Sig.	Sig.	NS	NS	NS
C.V.%	5.86	5.85	9.28	9.13	9.25

Table 4: Yield attributes and Yield as influenced by method of nitrogen application and nitrogen sources interaction

Treatment combination	Length of husked baby corn (cm)	Length of dehusked baby corn (cm)	Weight of husked corn plant^{-1} (g)	Weight of dehusked corn plant^{-1} (g)	Husked baby corn yield (q ha^{-1})	Dehusked baby corn yield (q ha^{-1})
M_1F_1	20.45	10.19	77.42	17.38	72.78	16.34
M_1F_2	18.48	9.21	75.72	17.00	70.26	15.77
M_1F_3	17.75	8.92	74.81	16.80	69.05	15.50
M_1F_4	21.58	10.25	84.77	19.03	79.92	17.95
M_2F_1	16.90	8.36	67.45	15.14	64.49	14.48
M_2F_2	16.58	8.49	65.52	14.71	64.37	14.45
M_2F_3	15.90	8.53	53.32	11.97	56.05	12.58
M_2F_4	17.20	8.71	64.72	14.53	62.86	14.12
S. Em. ±	0.50	0.27	2.35	0.54	1.98	0.44
CD (P=0.05)	1.47	0.80	6.99	1.60	5.87	1.32
C.V. %	5.47	5.93	6.68	6.82	5.86	5.85

M_1: Drip nitrogen fertigation M_2: Traditional base application (soil application) F_1: Urea F_2: Urea Phosphate F_3: Calcium Nitrate F_4: Ammonium Sulphate CD - Critical Differences (5% level significant), S. Em. ± - Standard Error mean and C. V.% - Coefficient of Variation

Table 5: Economics of baby corn as influenced by method of nitrogen application and nitrogen sources interaction

Treatment combination	Baby corn yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Gross realization (ha^{-1})	Total cost of cultivation (ha^{-1})	Net realization (ha^{-1})	BCR
M_1F_1	1634	6339	172909	32077	140832	5.4
M_1F_2	1577	6166	166949	38567	128382	4.3
M_1F_3	1550	5771	163656	79412	84244	2.1
M_1F_4	1795	6610	189415	38012	151403	5.0
M_2F_1	1448	5179	152569	32710	119858	4.7
M_2F_2	1445	5098	152147	39200	112947	3.9
M_2F_3	1258	4334	132301	80045	52256	1.7
M_2F_4	1412	5691	149737	38645	111093	3.9

M_1: Drip nitrogen fertigation M_2: Traditional base application (soil application) F_1: Urea F_2: Urea Phosphate F_3: Calcium Nitrate F_4: Ammonium Sulphate, BCR: Benefit and Cost Ratio
Sale price of dehusked baby corn – 100 ` kg^{-1}
Sale price of stalk of baby corn crop – 1.50 ` kg^{-1}

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