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Effect of Integrated Nitrogen Management on Yield and Nitrogen Uptake by Sweet Corn

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A field experiment were conducted at Agricultural Research Station, Banawara during *zaid* season, 2010 and 2011 on clay loam soil to find out the optimum levels of nitrogen, *Azotobacter* inoculation and nitrogen sources. The experiment comprising of thirty treatment combinations with three levels of nitrogen (75 % , 100% and 125% RDN), two *Azotobacter* (seed inoculation and without inoculation) and five nitrogen sources (100% fertilizer-N, 50% poultry manure + 50% fertilizer-N,100% poultry manure , 50% *jatropha* cake + 50% fertilizer-N and 100% *jatropha* cake) were laid out in split plot design with four replications. Significant increase in yield, nitrogen uptake and available nitrogen in the soil were recorded under application of 125% RDN level over 75% RDN and 100% RDN levels.The *Azotobacter* inoculation recorded significantly higher yield of sweet corn, nitrogen uptake and available nitrogen in soil at crop harvest over no inoculation. In case of different nitrogen sources significant increase in green cob (7.93 t/ ha), green fodder (19.54 t/ha) and biological (27.47 t/ha) yields of sweet corn were recorded under application of 50% poultry manure + 50% fertilizer-N over rest of nitrogen sources but found at par with100% fertilizer-N. Application of 100% fertilizer-N and 50% poultry manure + 50% fertilizer-N were found at par in respect of nitrogen uptake by cobs, fodder and total uptake by crop but found superior over 100% poultry manure, 50% *jatropha* cake + 50% fertilizer-N and 100% *jatropha* cake, respectively. The maximum available nitrogen in the soil was recorded under application of 100% fertilizer-N over 50% poultry manure + 50% fertilizer-N,100% poultry manure, 50% *jatropha* cake + 50% fertilizer-N and 100% *jatropha* cake, respectively.

Key words: Sweet corn, RDN, *Azotobacter*, Poultry manure and *Jatropha* cake

Sweet corn is a special type of corn used for table purpose. It is one of the most popular vegetables in USA, Europe and other advanced countries of the world. In India, it covers an area of 8.33 m ha with the production and productivity of 16.68 million tonnes and 2002 kg ha^{-1}, respectively (Directorate of Economics and Statistics,2010).It ranks fifth in area and sixth in production. In the state of Rajasthan it covers an area of 1.05 m ha with production and productivity of 1.95 m t and 1860 kg ha^{-1}, respectively (Government of Rajasthan, 2010). The productivity of this crop in the country as well as the state of Rajasthan appears meager in front of world average (4200 kg ha^{-1}). For diversification and value addition of maize as well as the growth of the food processing industry, growing maize for vegetable purpose, which is known as 'sweet corn' "(*Zea mays* L. sub sp. *Saccharata*)", is contemplated. Now-a-days, sweet corn is becoming popular in India and is being cultivated in maize growing areas. The urban people have great interest in consuming green ears and it is found that sweet corn is more delicious when it is steam boiled and consumed. Due to its extra sweetness and short duration, sweet corn is gaining popularity and already awareness has been created among the farming community. As the product is freshly consumed, the quality of corn is considered to be the most important.

Among the plant nutrients, nitrogen is the most important element for plant growth and development. Maize is an exhaustive crop and requires high quantities of nitrogen during the period of efficient utilization, particularly at 25 days after sowing and pre-tasseling (40 days after sowing) stages for higher productivity. Sweet corn yield has been found to increase as the amount of nitrogen increases (Bravo, *et al*., 1995).

Although increased level of production can be achieved by increased use of inorganic fertilizers alone but it may lead to pollution problem and deterioration in soil characteristics and soil fertility (Gaur and Kumawat, 2000). This can only be maintained at sustainable level by the application of organic manures and microbial inoculations. The role of soil organic carbon in maintaining soil fertility and productivity is well recognized from the time immemorial and its maintenance in the soil is of

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utmost concern under modern intensive farming. Amongst the organic manures, poultry manure and *Jatropha* oil cake are well known sources, which release nutrients in readily available form after microbial decomposition. The results of long-term addition of organic manures in to the soil have resulted in favourable influence on physical, chemical and biological properties of the soil (AICMIP, 1989). Inoculation with *Azotobacter* culture has been found promising in improving nitrogen status in the soil and resulted in increased crop yield. *Azotobacter* is able to fix atmospheric nitrogen through non-symbiotic process (Somani, 1987).

The *jatropha* seed cake and poultry manure are rich in nitrogen, phosphorous and potassium and can be used as manures (Chaplot, 2010). Amongst the organic manures, poultry manure and *Jatropha* oil cake are well known sources, which release nutrients in to readily available form after microbial decomposition. integrated use of nitrogen fertilizer in conjunction with organics and bio-fertilizer in sweet corn can be a more efficient and judicious approach than chemical fertilizer. Therefore, the study was undertaken to evaluate the effect of chemical fertilizer, biofertilizer and organic nitrogen sources on sweet corn yield, nitrogen uptake and nitrogen status of soil.

Materials and Methods

A field experiment was conducted during *zaid* 2010 and 2011 at Agricultural Research Station, Banswara, which is situated at $23_0 5'$ N latitude, $74_0 5'$ E longitude and at an elevation of 268 m above mean sea level. This region falls under agro-climatic zone IV b (Humid Southern Plain) of Rajasthan. The average annual rainfall of the region is 894.8 mm, most of which is contributed by South-West mansoon from July to September. The soils was (black cotton soil) clay loam texture and alkaline in reaction (pH 7.9), organic carbon (0.68 g kg_{-1} soil), medium in available nitrogen (245 kg ha_{-1}) and phosphorus (48.40 kg ha_{-1}) and high in available potassium (320 kg ha_{-1}). The treatments comprised combinations of three nitrogen levels in main plot (75% RDN, 100% RDN and 125% RDN), two *Azotobacter* inoculation in sub plot (seed inoculation and without inoculation) and five nitrogen sources in sub-sub plot (100% fertilizer- N, 50% poultry manure + 50% fertilizer-N, 100% poultry manure , 50% *jatropha* cake + 50% fertilizer-N and 100% *jatropha* cake), thereby, making thirty treatment combinations were replicated four folds in split plot design.The crop was sown in same field in both the assessment years. Nitrogen @80 kg ha_{-1} was applied through urea, poultry manure and *jatropha* cake (adjusted for its N content) half dose as basal in ploughed furrows before sowing. The remaining half dose of nitrogen was applied through same sources at 25-30 DAS and 40 kg P_2O_5 ha^{-1} as basal through SSP. The seed of sweet corn were inoculated with *Azotobacter* inoculant (25 g $kg_{-1}$of seed) just before sowing. Carrier based inoculants was suspended in 10% jaggery solution and the seeds were thoroughly mixed in it to have uniform coating and then allowed to dry in the shade before the sowing of crop. Furrows were opened at 60 cm apart for maintaining the plant population of 83333 plants ha_{-1}, thinning was carried out at 20 DAS and maintain 20 cm plant to plant distance.

Green cobs obtained from each plot were weighed and used to compute green cob yield, soon after picking of green cobs, the crop was harvested and bundled according to individual plot and weighed to obtain final green fodder yield and biological yield was calculated by summing up the individual plot green cob and green fodder yields (kg ha_{-1}).The N uptake was estimated by multiplying dry matter yield (kg ha_{-1}) with per cent nitrogen content .Nitrogen status of the soil at harvest of the crop by Alkaline $KMNO_4$ method (Subbiah and Asija, 1956).The trend of response of all the treatments under study remained the same during both the years. Hence results were discussed as per pooled analysis.

Results and Discussion

Effect of nitrogen levels

The significantly higher value of green cob, green fodder and biological yields as well as nitrogen uptake by cobs, fodder and total uptake by crops and available nitrogen in soil at harvest of sweet corn were recorded with application of 125% RDN over 100% and75% RDN but in case of green cob yield and nitrogen uptake of cob, significantly higher, value recorded with 100% RDN over 75% RDN. Application of 125% RDN gave higher green fodder yield (20.68 t/ha) by 18.5 and 6.8 per cent and biological yield (28.65 t/ha) by 15.3 and 5.2 per cent as compare to 75% RDN and 100% RDN levels, respectively (Table 1). Hence, marked increase in

Table 1. Effect of nitrogen levels, *Azotobacter* inoculation and nitrogen sources on yield of sweet corn (kg ha_{-1})

Treatment	Green fodder yield	Green cob yield	Biological yield
Nitrogen Levels			
75% RDN	7360.25	17454.25	24814.50
100% RDN	7870.25	19354.25	27224.50
125% RDN	7972.75	20685.50	28658.25
SEm ±	54.72	154.38	186.88
CD (P = 0.05)	158.06	445.89	539.75
Azotobacter Inoculation			
Inoculation with *Azotobacter*	7888.83	19577.41	27466.25
No inoculation	7580.00	18751.91	26331.91
SEm ±	44.68	126.05	152.58
CD (P = 0.05)	129.06	364.07	440.71
Nitrogen Sources			
100% Fertilizer-N	7806.50	19361.66	27168.16
50% Poultry manure + 50% Fertilizer-N	7931.50	19545.00	27476.50
100% Poultry manure	7654.41	19076.25	26730.66
50% *Jatropha* cake + 50% Fertilizer-N	7750.25	19117.91	26868.16
100% *Jatropha* cake	7529.41	18722.50	26251.91
SEm ±	56.59	125.26	133.68
CD (P = 0.05)	158.20	350.14	373.69
Interaction N levels X *Azotobacter* inoculation	NS	NS	NS

green cob yield with fertilization of higher nitrogen level seems to be due to more exploitation of crop genetic potential for vegetative and reproductive growth. These are in close conformity with the findings of Raja, 2001. In case of nitrogen uptake application of 125% RDN recorded higher nitrogen uptake by cobs (33.41kg ha-1) by 10.8 per cent , by fodder (48.10 kg ha-1) by 64.10 and 32.10 per cent and total nitrogen uptake (81.51 kg ha-1) by 37.1 and 17.8 per cent over 75 % RDN and 100% RDN, respectively (Table 2). It is an established fact that the uptake of nitrogen usually follows the yield pattern

Table 2. Effect of nitrogen levels, *Azotobacter* inoculation and nitrogen sources on nitrogen uptake by crop & nitrogen status of soil at crop harvest (kg ha-1)

Treatment	N uptake by Cobs	N uptake by Fodder	Total N uptake	At crop harvest
Nitrogen Levels				
75% RDN	30.13	29.30	59.44	279.75
100% RDN	32.77	36.39	69.17	291.70
125% RDN	33.41	48.10	81.51	297.38
SEm +	0.26	0.28	0.46	0.43
CD (P = 0.05)	0.76	0.82	1.34	1.26
Azotobacter Inoculation				
Inoculation with *Azotobacter*	32.98	40.15	73.13	291.98
No inoculation	31.23	35.72	66.95	287.24
SEm +	0.21	0.23	0.37	0.35
CD (P = 0.05)	0.62	0.67	1.09	1.03
Nitrogen Sources				
100% Fertilizer-N	33.18	39.10	72.29	292.54
50% Poultry manure + 50% Fertilizer-N	32.96	39.09	72.05	290.95
100% Poultry manure	31.86	37.25	69.12	288.31
50% *Jatropha* cake + 50% Fertilizer-N	32.19	37.91	70.10	289.66
100% *Jatropha* cake	30.31	36.30	66.62	286.58
SEm +	0.26	0.32	0.40	0.49
CD (P = 0.05)	0.74	0.89	1.12	1.36
Interaction N levels X *Azotobacter*	Sig	Sig.	NS	Sig.

as the amount of nitrogen taken up per unit amount of biomass production determines the yields, since the essential nitrogen are involved in the metabolism of the plants. Similar trends also observed in nitrogen status of soli that application of 125% RDN gave higher nitrogen status in the soil (297.38 kg ha-1) by 6.3 and 1.9 per cent over 75% RDN and 100% RDN, respectively (Table 2).

***Effect of* Azotobacter**

Seed inoculation with *Azotobacter* produced higher green cob yield of sweet corn (7.88 t/ha) by 4.0 per cent green fodder yield (19.57 t/ha) by 4.4 per cent and biological yield (27.46 t/ha) by 4.3 per cent (Table 1) over no inoculation treatment. The similar trend was also observed in nitrogen uptake by crop seed inoculation with *Azotobacter* recording higher nitrogen uptake by cobs (32.98 kg ha-1) by 5.6 per cent by fodder (40.15 kg ha-1) by 12.4 per cent and total nitrogen uptake (73.13 kg ha-1) by 9.2 per cent over no inoculation (Table 2). The improvement in yield of sweet corn was limited when the *Azotobacter* inoculation was used singly (either N_2-fixers). However, when N_2 fixers was recorded significant additive effect. Such mutually beneficial synergistic effect has also been reported by (Dilshad *et al*., 2010). Nitrogen uptake is a product key of yield and nitrogen content, considerable increase in either nitrogen content or in yield may increase the uptake. The results are in confirmation with findings of (Das *et al*., 2010 and Balai *et al*., 2011). Available nitrogen status of the soil increased significantly under seed inoculation with *Azotobacter* over no inoculation. Seed inoculation with *Azotobacter* inoculation gave higher available nitrogen in the soil (291.98 kg ha-1) by 1.6 per cent over no inoculation (Table 2).

Effect of nitrogen sources

Application of 50% poultry manure + 50% fertilizer-N recorded the highest cob yield of 7.93 t/ha, green fodder yield (19.54 t/ha) by 2.4, 2.2 and 4.3 per cent and biological yield (27.47 t/ha) by 2.8, 2.2 and 4.6 per cent as compared to 100% poultry manure, 50% *jatropha* cake + 50% fertilizer-N and 100% *jatropha* cake, respectively but at par with100%

Table 3. Interaction effect of nitrogen levels and *Azotobacter* Inoculation on nitrogen uptake by ccbs, fodder and nitrogen status in soil at crop harvest Kg ha-1 (Pooled data of 2010 and 2011)

Azotobacter	Nitrogen levels (% RDN)								
	Cobs			Fodder			Nitrogen status		
	75	100	125	75	100	125	75	100	125
Inoculation with *Azotobacter*	31.47	33.08	34.40	30.16	39.90	50.39	283.03	294.58	298.35
No inoculation	28.80	32.46	32.42	28.45	32.90	45.81	276.48	288.83	296.43
SEm +	0.0373*	0.047**		0.405*	0.535**		0.618*	0.818**	
CD (P = 0.05)	1.077*	1.370**		1.171*	1.547**		1.786*	2.363**	

*CD for *Azotobacter* inoculation mean at same level of nitrogen mean

**CD for nitrogen level mean at same *Azotobacter* inoculation

fertilizer- N (Table 1). The combined application of mineral fertilizer and organic manures is an appropriate method to achieve higher yields. The biological yield is a function of grain and straw yield, representing vegetative and reproductive growth of the crop. The results are in close agreements with the findings of (Singh *et al*., 2009). In case of nitrogen uptake application of 100% fertilizer-N was observed at par with 50% poultry manure + 50% fertilizer-N and recorded significantly higher nitrogen uptake by cobs (33.18 kg ha-1) by 4.1, 3.0 and 9.4 per cent, nitrogen uptake by fodder (39.10 kg ha-1) by 4.9, 3.1and 7.7 per cent and total nitrogen uptake by the crop (72.29 kg ha^{-1}) by 4.5, 3.1and 8.5 per cent over 100% poultry manure, 50% *jatropha* cake + 50% fertilizer-N and 100% *jatropha* cake, respectively (Table 2) . The uptake of nitrogen is a numerical function of its concentration in plant and biomass production. Hence the increased nitrogen uptake by cob and fodder as well as crop as a whole can be ascribed to higher yield. The available nitrogen status of the soil was the highest under application of 100% fertilizer-N closely followed by 50% poultry manure + 50% fertilizer-N and both these nitrogen levels recorded significantly higher nitrogen status of the soil at crop harvest over 100% poultry manure, 50% *jatropha cake* + 50% fertilizer-N and 100% *jatropha* cake. Application of 100% fertilizer-N gave significantly higher available nitrogen status in the soil (292.54 kg ha^{-1}) which was higher by 0.54, 1.46, 0.99 and 2.0 per cent (Table 2) over 50% poultry manure + 50% fertilizer-N, 100% poultry manure , 50% *jatropha cake* + 50% fertilizer-N and 100% *jatropha* cake, respectively. The significant build up of available nitrogen status under this treatment could be attributed to adequate supply of nitrogen to meet the crop requirement further, increased their concentration in the soil. The result of present investigation strongly supports the findings of (Das *et al.*, 2008).

Interaction effect between nitrogen levels and* Azotobacter *inoculation

It is evident from data (Table 3) that under seed inoculation with *Azotobacter* and application of 125% RDN showed significant increase nitrogen uptake by cob and fodder over 75% RDN but was found at par with 100% RDN. While without seed inoculation, application of 100% RDN was observed significant increase in nitrogen uptake by cob and fodder over 75% RDN level but was found at par with 125% RDN. In case of available nitrogen in soil at 75% RDN, 100% RDN and 125% RDN, seed inoculation with *Azotobacter* recorded significantly higher available nitrogen in the soil at crop harvest over same levels of nitrogen without seed inoculation.

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