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IMPACT OF NITROGEN LEVELS AND APPLICATION METHODS ON AGRONOMIC, PHYSIOLOGICAL AND NUTRIENT UPTAKE TRAITS OF MAIZE FODDER

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Abstract

Field investigations were carried out to test the effect of varying levels of nitrogen (0, 60, 100, 140 and 180 kg ha^{-1}) applied through different application methods viz., broadcast, fertigation and side dressing on maize variety Akbar for fodder production. Nitrogen fertigation had better efficiency over broadcast and side dressing. Maximum leaves plant^{-1} (15.1), stem girth (6.86 cm), green fodder yield (91.25 t ha^{-1}), total dry matter (8.90 t ha^{-1}), leaf area index (15.57), leaf area duration (201 days), N content (1.35%) and N uptake (120.42 kg ha^{-1}) were noted with the application of 140 kg N ha^{-1} through fertigation. Further increase in nitrogen had non-significant response on these traits. Higher N regime 180 kg ha^{-1} through fertigation increased growth traits viz., plant height (199 cm) and crop growth rate (16.90 g m^{-2}day^{-1}), followed by broadcast application of 180 kg N ha^{-1}. It is concluded that application of 140 kg N ha^{-1} through fertigation method was an optimum N dose for the maize fodder production.

Introduction

Nitrate contamination of groundwater can be minimized by management techniques such as avoiding excessive nitrogen, splitting N fertilizer applications (Ritter *et al*., 1993; Martin *et al*., 1994), adjusting side dressed N application rates based on N tests (Ritter *et al*., 1993). An adequate supply of nutrients is essential for optimum growth and development of maize (Cox *et al*., 1993). Positive response of maize fodder yield to nitrogen fertilizer has been reported by Aflakpui *et al*., (1997). The application of nitrogen not only affects the forage yield of maize but also improves its quality especially its protein contents (Khandaker & Islam, 1988), nutritive value by reducing ash and fiber contents and digestible dry matter yield (Muhammed & Hamed, 1988). The efficiency of utilization of applied N depends on its rates (Gromove *et al*., 1994).

Concerns about best management practice are increasing because mismanagement of nitrogenous fertilizer can lead to contamination of ground and surface water sources as well as soil degradation and can cause health problems (Anon., 1990). Placement of fertilizer is an integral part of efficient crop management. It can affect both crop yield and nutrient-use efficiency (Johnston & Flower, 1991). Band application of fertilizer gave higher yield than broadcast (Hussain, 1976; Rafique & Afzal, 1982; Khattak *et al.,* 1988). Banding and side dressing N in corn may have disadvantages because the knives of the side dress fertilizer applicator will prune roots, seedlings may be injured by the NH_3 released as nearby banded urea (Sojka *et al*., 1994). However, Tyler & Howard (1991) concluded that the nutrient status of soils with band fertilization could be evaluated effectively with random sampling. Subsurface banding with planter usually 5 cm beside and below the seeds can significantly increase fertilizer use efficiency, crop nutrient uptake and yield compared with broadcast fertilization (Lauson & Miller, 1997).

The advantages of fertigation showed a slow-release of fertilizer and lower loss of N and therefore a lower degree of ground water contamination which not only increased the N uptake by the plant as well as the leaf and root weight, but it also produced higher yields (Cadahia, 1993). Fertigation technique can reduce fertilizer application costs by eliminating an operation and improve nutrient efficiency. Also, it could conceivably reduce leaching or de-nitrification (gaseous) losses of nitrogen and lower the luxury uptake of nutrients by plants. Fertigation enables users to put the fertilizers in plant root zone or on canopy in desired frequency, amount and concentration at appropriate time (Kumar *et al*., 2000). Carefoot *et al*., (1990) reported that difference in yield and N derive from fertilizer were related to mobilization of Ammonium nitrate, this depends on the degree of contact between the fertilizer, root and soil moisture levels. Lower recovery of N has been attributed to immobilization of N with surface application of nitrogenous fertilizer (Fredrickson *et al*., 1982). Previous research suggests that because of possibilities of increased immobilization of broadcast N, bending fertilizer N below the surface residue layer may be necessary (Malhi *et al*., 1985). Efficient use in fertilizer requires contact between fertilizer and crop requirements, which could be achieved by placing N below surface (Rice & Symth, 1994). Thus, 50% of recommended dose of fertilizer application through fertigation was as effective to produce yield as that of conventional method of fertilizer application (Tumbare, 1999) and 25-50% fertilizer could be saved. Thus, a saving of 30-15-15 kg NPK ha^{-1} was recorded through fertigation application against the recommended NPK levels (Balasubramanian *et al*., 1999). The objectives of this research, therefore, were to determine how different N application methods and levels can enhance maize fodder production and better alternative of nitrogen management practices to the farmers for higher crop productivity.

Materials and Methods

Field research was conducted at Students Farm, Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan, located at 25°25’60’N 68°31’ 60E, altitude 19.5 m asl. Soil was clay loam in texture, non saline, EC (0.96 dS/m), slightly alkaline in reaction pH (7.8), calcareous ($CaCO_3$ 9.8%), low in organic matter (0.8%), total nitrogen content (0.04%) and available phosphorus (3.8 mg kg^{-1}), however high in exchangeable potassium (170 mg kg^{-1}). The treatments were set in randomized complete bock design in factorial arrangement, replicated three times.

Cultural practices: Land was prepared by deep plowing followed by leveling for equal distribution of irrigation and eradication of weeds. All P (65 kg ha^{-1}) in the form of SSP was applied at the time of sowing. Varying levels of nitrogen (0, 60, 100, 140 and 180 kg ha^{-1}) were split applied during sowing, 2nd and 3rd irrigations through different methods (broadcast, fertigation and side dressing) to maize variety Akbar. The crop for green fodder was harvested at 50% tasselling.

N application methodology

Broadcast: Nitrogen fertilizer was applied as urea on the surface of soil.

Fertigation: Urea as per N treatment was diluted in water (as per calibration) and filled in container having a small hole. The container was kept on the water channel of the plot to pass-out the water-urea concentration.

Side dressing: Nitrogen fertilizer as urea was applied along with the side of plants through hand driven single coulter drill, about 0-3 inches away from the plants.

Statistical analysis: Data were statistically analyzed through MSTATC computer software. The LSD value for mean comparison was calculated only if the general treatment *F* test was significant at a probability of ≤ 0.05 (Gomez & Gomez, 1984).

Determination: Standard procedures were followed to record data on seedling emergence, leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR), total dry matter (TDM), N content, N-uptake, green leaves plant^{-1}, plant height, stem girth and green fodder yield.

Results and Discussion

Application of nitrogen through different N application methods significantly increased physiological and agronomic traits of maize, however, emergence showed non-significant response. Maximum leaf area index (15.57), leaf area duration (201 days), total dry matter (8.90 t ha^{-1}), N content (1.35), N uptake (120.42 kg ha^{-1}), leaves plant^{-1} (15.1), stem girth (6.86 cm), green fodder yield (91.25 t ha^{-1}), were found with the application of 140 kg N ha^{-1} applied through fertigation. Beyond this dose, no significant increases were detected except plant height (199 cm) and crop growth rate (16.90 g m^{-2}day^{-1}), all these traits increased as the N rate increased from 140 to 180 kg N ha^{-1} applied as fertigation (Tables 1 & 2).

In this study, increased maize growth and yield with optimum fertilizer N (140 kg N ha^{-1}) application is consistent with the studies of Sallah *et al*., 1998; Njui & Musandu, (1999) and Halvorson *et al*., (2006). However, it is also reported that maize yield increases with the application rate of nitrogen fertilizer until it reaches a plateau, beyond which N applications do not affect corn yield (Schmidt *et al*., 2002). Understanding the N fertilizer response of maize can help producers effectively manage N for positive combinations of high maize productivity with minimal adverse environmental impacts (Fox *et al*., 1989). The most logical approach to increasing N fertilizer use efficiency is to supply N as it is needed by the crop (Keeney, 1982). Current N recommendations generally are based on previous and expected yields. This practice leads to over–fertilization in some areas, but under–fertilization in others (Mamo *et al*., 2003). Over–fertilization with N has become an issue of much debate among scientists, regulatory agencies and policy makers (Crandall *et al*., 2005). Nitrate–N contamination of ground and surface waters can result in public health risks (Goss & Barry, 1995; Nolan & Stoner, 2000; Shankar *et al*., 2000), impairment of aquatic life and recreation in water resources (Keeney, 1982; McIsaac *et al*., 2001). Maize research across more than 460 field studies in Ontario, Colorado, Illinois, Iowa, Michigan, Minnesota, Wisconsin etc., showed variation in the recommended N rate explained less than 10% of the variation in the actual economically optimum N rate (Davis *et al*., 1996; Harrington *et al*., 1998; Fleming *et al*., 2000). Therefore, Ma *et al*., (1999) suggested that fertilizer N is the most costly input in maize production and its effective management is a major challenge for improving productivity and environmental sustainability.

Table 1. Physiological and N uptake traits of maize fodder as affected by N levels and application methods.

Treatments		LAI	LAD (days)	CGR ($gm^2 day^{-1}$)	TDM ($t\ ha^{-1}$)	N content (%)	N uptake ($kg\ ha^{-1}$)
Application methods	N levels ($kg\ ha^{-1}$)						
Broadcast	00	3.57 h	46 h	14.92 ij	8.03 fg	0.27	21.87 i
	60	5.72 h	73 f	15.30 gh	8.20 efg	0.49	39.87 g
	100	7.69 d	99 d	15.50 f	8.30 def	0.75	61.89 d
	140	11.27 b	145 b	15.90 d	8.50 cd	1.09	92.53 b
	180	11.20 b	144 b	16.15 c	8.65 bc	1.07	92.66 b
Fertigation	00	3.50 h	45 h	15.00 ij	8.05 fg	0.26	20.71 i
	60	6.73 e	86 e	15.70 e	8.40 cde	0.58	48.90 f
	100	10.57 c	136 c	16.07 c	8.60 c	0.88	75.52 c
	140	15.57 a	201 a	16.60 b	8.90 ab	1.35	120.42 a
	180	15.63 a	200 a	16.90 a	9.05 a	1.33	120.79 a
Side dressing	00	3.55 h	46 h	14.90 j	8.00 c	0.25	20.13 i
	60	4.82 g	62 g	15.15 hi	8.12 efg	0.45	36.51 h
	100	5.64 f	72 f	15.35 fg	8.22 defg	0.66	54.14 e
	140	7.65 d	98 d	15.70 e	8.40 cde	0.88	73.91 c
	180	7.63 d	98 d	15.90 d	8.50 cd	0.87	73.89 c
LSD (5%)		0.0278	3.42	0.157	0.255	-	2.173

Means followed by common letter are not significantly different at 5% probability level

Table 2. Agronomic traits of maize fodder as affected by N levels and application methods.

Treatments		Emergence (%)	Leaves $plant^{-1}$	Plant height (cm)	Stem girth (cm)	Green fodder yield ($t\ ha^{-1}$)
Application methods	N levels ($kg\ ha^{-1}$)					
Broadcast	00	86.08	10.0 e	65 j	2.56 g	17.33 g
	60	84.75	10.0 e	91 h	3.62 f	34.75 f
	100	84.75	10.9 d	120 f	4.45 e	59.50 d
	140	84.25	13.1 b	159 d	5.17 c	75.25 b
	180	84.75	13.0 b	169.c	5.23 c	79.50 b
Fertigation	00	84.75	9.6 e	65 j	2.59 g	18.50 g
	60	85.00	10.7 d	111 g	4.40 e	43.50 e
	100	84.75	13.0 b	149 e	5.62 b	70.25 c
	140	84.75	15.1 a	193 b	6.86 a	91.25 a
	180	84.25	15.0 a	199 a	6.85 a	94.00 a
Side dressing	00	84.50	10.0 e	66 j	2.55 g	17.75g
	60	84.75	10.0 e	82 i	3.65 f	31.00 f
	100	84.50	10.0 e	90 h	4.32 e	40.75 e
	140	84.75	12.0 c	110 g	4.72 d	56.00 d
	180	84.75	11.8 c	114 g	4.80 d	57.75 d
LSD (5%)		-	0.382	4.126	0.159	3.713

Means followed by common letter are not significantly different at 5% probability level.

In this study, N broadcast or side dressing methods even at higher N rates (180 kg ha^{-1}) did not result in recording higher values of crop parameters as compared to N-fertigated plots. This may be the reason that N-fertigated plots received equal amounts of N and distributed uniformly in the field through irrigation water. Thus, N fertigation at 140 kg ha^{-1} was efficient method which saved 40 kg N ha^{-1} over rest of placement methods and recorded higher plant N content (1.35%) and N uptake (120.42 kg ha^{-1}). Many researchers have reported that usually the crop uses 30 to 50% of the inorganic nitrogen fertilizer applied, the rest is lost by volatilization, de-nitrification or leaching as nitrate into the groundwater (Stewart *et al*., 2005), thus nitrate contamination of groundwater can be minimized by avoiding excessive nitrogen (Russelle *et al*., 1981). Adequate fertilizers led to increase the crop yields, improves the nutrient element concentration in plant tissue and soil macro and micro nutrient status (Adediran *et al*., 2004) and can give 67% more yield over control (Taiwo *et al*., 2001). Fertigation in this regard had a consistent effect on total nitrogen use efficiency (Hou *et al*., 2007) and more uniform N distribution (Jiusheng *et al*., 2005). N fertigation maintained high concentrations of NO_3-N at shallower depths than did broadcast or any other N application method (Hebbar *et al*., 2004).

Conclusions

Overall results of the present investigations conclude that N fertigation method maximized all the agronomic, physiological and N uptake traits of maize fodder and ultimately resulted in higher maize fodder production.

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