

Full Length Research Paper

Consequences of diverse use of nitrogen sources on grain yield, grain quality and growth attributes of hybrid maize (*Zea mays* L.)

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Accepted 17 February, 2012

A two year field experiment was conducted to check the consequences of diverse use of nitrogen sources on grain yield, grain quality and growth attributes of hybrid maize (*Zea mays* L.) at the Agronomic Research Area, University of Agriculture, Faisalabad during Autumn 2008 and 2009. Experiments were laid out in a randomized complete block design with factorial arrangement comprising 3 replications with a net plot size of 3 × 5 m. Treatment comprised two hybrids: that is, H₁ (Pioneer-30Y87) and H₂ (Pioneer-31R88) with combination of six nitrogen sources S₀ : Control (0) kg N ha⁻¹, S₁: Urea (50%) + Poultry manure (50%), S₂: Urea (50%) + Farm Yard Manure (50%) , S₃: Urea (50%) + Pressmud of sugarcane manure (50%), S₄: Urea (50%) + Compost (50%), S₅: Urea (50%) + (PM+FYM+PMS+ Compost) 50% . Results of grain yield (t ha⁻¹), grain protein content (%), grain oil content (%), leaf area index, leaf area duration, dry matter accumulation, crop growth rate and net assimilation rate was found to be significant during 2008 and 2009. It was concluded that hybrid maize H₁ (Pioneer - 30Y87) produced better grain yield (6.14 t ha⁻¹) during 2008 when nitrogen sources S₁: Urea (50%) + Poultry manure (50%) was applied in combination as compared to grain yield (6.0 t ha⁻¹) in hybrid H₂ (Pioneer -31R88) during 2009. Growth and quality attributes also performed better in 2008 as compared to 2009 at nitrogen sources S₁: Urea (50%) + Poultry manure (50%).

Key words: Nitrogen sources, hybrid maize, yield, growth, quality.

INTRODUCTION

Nitrogen plays a dominant role in different growth process of plants, because it is an integral part of chlorophyll and enzyme (Power and Schepers, 1989). Application of nitrogen at rates of 0,168, 336, 504 and 672 kg ha⁻¹ to maize in municipal solid waste amended soil, increased total dry matter and total plant nitrogen (Erikson et al., 1999).

It is highly nutritive and its seed contains starch (78%), protein (10%), oil (4.8%), fibre (8.5%), sugar (3.1%) and ash (1.7%) (Chaudry, 1983). Poultry manure at the rate

of 5 t ha⁻¹ and 10 t ha⁻¹ enhanced the maize production by 39 to 43% immediately, and on residual basis it increased yield 73 and 93%. Combination of 5 t ha⁻¹ cocca pod ash and poultry manure 10 t ha⁻¹ gave the highest yield of 6.5 and 5.58 t ha⁻¹ on weight basis (Ayeni et al., 2010).

Pressmud from the sugarcane is also a useful source of fertilizer as well as some chemicals, its usefulness is based on nutrient content of mud and spent wash (Partha and Sivasubramanian, 2006). Agronomic efficiency and nitrogen use efficiency can be enhanced by using the combination of 75% nitrogen (urea) +25% organic sources like farm yard manure (Shah et al., 2010).

Adejumo et al. (2010) conducted an experiment to evaluate the relative effect of municipal solid waste

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(MSW) and cassava waste along with inorganic fertilizer on maize crop yield in lead affected soils. It was concluded that use of compost increased yield compared to inorganic fertilizers. Higher dose of MSW caused to increase plant height, dry matter yield, leaf area and grain yield. It was also observed that there was a significant reduction in soil lead concentration of all compost rates used. The maize root analyzed showed the uptake of lead by roots move in compost applied field compared to inorganic fertilizers. Therefore, it was concluded that different composites can be used for restoration of lead sites.

Organic matter (O.M.) and the total N status declined with the application of fertilizer N alone but increased with integrated use of fertilizer N and O.M. build up in S status was mostly through the organic S fertilizer. The use of FYM and green manure increased the K availability in the soil. The combined application of O.M. and inorganic N sustained the productivity even at lower level of N application. Incorporation of 5 t FYM and 6 t green manuring saved 70 to 80 kg N ha⁻¹ (Muneshwar et al., 2001).

A number of factors are responsible for low yield of the crop. Inappropriate crop nutrition management and poor soil fertility are the most important factors responsible for the low yield. Soil fertility can be enhanced through the application of mineral fertilizers as well as with the addition of O.M. to the soil. Nevertheless, imbalanced use of fertilizer without the application of organic manure and without knowing the requirements of crops and fertility status of soil causes problems such as deterioration of soil structure, environmental and ground water pollution etc. Similarly, continuous use of chemical fertilizer caused the depletion of soil fertility. Organic matter improves the soil health and availability of nutrients. Organic materials are available in large amounts in the form of farm waste, city waste, poultry litter and industrial waste (food, sugar, cotton and rice industry).

MATERIALS AND METHODS

A two year field experiment was conducted to evaluate the consequences of diverse use of nitrogen sources on grain yield, grain quality and growth attributes of hybrid maize (*Zea mays* L.) was carried out at the Agronomic Research Area, University of Agriculture, and Faisalabad during Autumn 2008 and 2009. Experiments were laid out in a randomized complete block design with factorial arrangement comprising three replications with a net plot size of 3 × 5 m. Treatment comprised two hybrids: that is, H₁ (Pioneer-30Y87) and H₂ (Pioneer-31R88) with combination of six nitrogen sources S₀: Control (0) kg N ha⁻¹, S₁: Urea (50%) + Poultry manure (50%), S₂: Urea (50%) + Farm Yard Manure (50%), S₃: Urea (50%) + Pressmud of sugarcane manure (50%), S₄: Urea (50%) + Compost (50%), S₅: Urea (50%) + (PM + FYM + PMS + Compost) 50%. A recommended dose of fertilizer was applied. Urea was used as inorganic nitrogen source in split doses at the rate of 250 kg N ha⁻¹ (half at sowing and half in two equal splits-half at knee height and remaining half at tasseling. All the organic

sources that is, farm yard manure, pressmud of sugarcane, compost and poultry manure were applied three week before sowing. Recommended 100 kg P ha⁻¹ and 100 kg K ha⁻¹ was applied at sowing time, that is, some from organic sources (poultry manure, farm yard manure, pressmud of sugarcane and compost) and remaining from inorganic sources, that is, Single Super Phosphate (SSP) and Sulphate of Potash (SOP). Soil sample were analyzed chemically for their nutrients status before sowing of crop. All other cultural practices were kept normal and uniform for all the treatments. Harvesting was done made on 25 November 2008 and 10 November 2009.

The following parameters like grain yield (t ha⁻¹), grain protein content (%) and grain oil content (%) leaf area index, leaf area duration, dry matter accumulation, crop growth rate and net assimilation rate were recorded and data regarding all the traits were collected using standard procedures and analyzed by using Fisher's analysis of Variance technique. LSD test at 5% probability was used to compare the differences among treatments means (Steel et al., 1997).

RESULTS AND DISCUSSION

Grain yield (t ha⁻¹)

Grain yield in both year 2008 and 2009 was significantly influenced by hybrid maize and nitrogen sources; data in Table 1 showed that in both years. Hybrid H₁ (6.14 t ha⁻¹ and 6.08 t ha⁻¹ in 2008 and 2009, respectively) produced higher grain yield compared to lower in hybrid H₂ (6.0 t ha⁻¹ and 5.91 t ha⁻¹), respectively. This was followed by S₂ (urea + FYM) source which increased grain yield over the integrated nitrogen sources. These results are similar to the findings of Sudhu and Kapoor (1999), Tamayo et al. (1997) and Waseem et al. (2007).

Different nitrogen sources also had significant effect on grain yield in both years. In 2008 nitrogen sources S₁ (7.05 and 6.92t ha⁻¹ in 2008 and 2009, respectively) produced highest grain yield while lowest grain yield was found in S₀ (3.73 and 3.73t ha⁻¹), respectively. These observations confirmed the findings of Sudhu and Kapoor (1999), Tamayo et al. (1997) and Waseem et al. (2007).

Significant interactive effects between maize hybrids and integrated nitrogen sources were observed during both years. In 2008, maximum grain yield was recorded in H₁S₁ (7.12 t ha⁻¹) while minimum was found in interaction of H₂S₀ (3.57 t ha⁻¹). In 2009 grain yield increasing trend was similar to 2008. Rizwan et al. (2003) and Sharif et al. (2004) also reported similar interactive effects in maize.

During 2008 contrasts comparison between two hybrids H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₄ VS S₅ was highly significant for grain yield (t ha⁻¹) and S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources), S₃ VS S₅ was having a non significant contrast comparison for grain yield (Table 2). As for contrast comparison during 2009 among the two hybrids H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen

Table 1. Impact of nitrogen sources on grain yield, grain protein content and grain oil content of hybrid maize during 2008 -2009

Treatment	Grain yield (t ha ⁻¹)		Grain protein content (%)		Grain oil content (%)	
	2008	2009	2008	2009	2008	2009
A-Hybrid						
H ₁ : Pioneer-30Y87	6.14 ^a	6.08 ^a	7.06 ^a	6.88 ^a	3.44 ^a	3.79 ^a
H ₂ : Pioneer-31R88	6.0 ^b	5.91 ^b	6.92 ^b	6.34 ^b	3.38 ^b	3.63 ^b
LSD = 0.05	0.02*	0.05*	0.02*	0.11*	0.029*	0.029*
B-Nitrogen Source						
S ₀ : Control 0 kg Nha ⁻¹	3.73 ^f	3.73 ^e	4.71 ^f	4.09 ^e	2.25 ^e	3.08 ^f
S ₁ : Urea (50%) + Poultry manure (50%)	7.05 ^a	6.92 ^a	8.25 ^a	8.09 ^a	4.09 ^a	4.39 ^a
S ₂ : Urea (50%) + Farm Yard Manure (50%)	6.63 ^b	6.57 ^b	7.47 ^c	6.47 ^d	3.84 ^b	3.80 ^c
S ₃ : Urea (50%) + Pressmud of sugarcane (50%)	6.40 ^d	6.33 ^c	7.34 ^d	7.49 ^b	3.27 ^d	3.65 ^d
S ₄ : Urea (50%) + Compost (50%)	6.19 ^e	6.16 ^d	6.23 ^e	6.75 ^c	3.51 ^c	3.28 ^e
S ₅ : Urea (50%)+(PM+FYM+PMS+Compost)50%	6.43 ^c	6.28 ^c	7.92 ^b	6.78 ^c	3.50 ^c	4.04 ^b
LSD = 0.05	0.05*	0.87*	0.03*	0.19*	0.052*	0.051*
C-Interaction (H x NS)						
H ₁ S ₀	3.57 ^l	3.57 ^j	4.81 ^k	4.19 ^g	2.39 ⁱ	3.16 ^h
H ₁ S ₁	7.12 ^a	7.02 ^a	8.17 ^b	8.21 ^a	4.19 ^a	4.57 ^a
H ₁ S ₂	6.91 ^c	6.80 ^b	7.59 ^f	7.61 ^b	3.95 ^b	3.66 ^f
H ₁ S ₃	6.59 ^f	6.45 ^{de}	6.97 ^h	7.59 ^b	3.35 ^g	3.77 ^e
H ₁ S ₄	6.69 ^e	6.65 ^c	5.96 ^j	7.01 ^c	3.59 ^e	3.49 ^g
H ₁ S ₅	6.01 ⁱ	6.01 ^g	8.01 ^c	6.67 ^{de}	3.19 ^h	4.07 ^c
H ₂ S ₀	3.90 ^k	3.90 ⁱ	4.61 ^l	4.00 ^g	2.12 ^j	2.99 ^j
H ₂ S ₁	6.99 ^b	6.82 ^b	8.33 ^a	7.97 ^a	4.0 ^b	4.21 ^b
H ₂ S ₂	6.35 ^g	6.35 ^e	7.35 ^g	5.33 ^f	3.73 ^d	3.95 ^d
H ₂ S ₃	6.21 ^h	6.21 ^f	7.71 ^e	7.39 ^b	3.19 ^h	3.54 ^g
H ₂ S ₄	5.70 ^j	5.66 ^h	6.51 ⁱ	6.50 ^e	3.44 ^f	3.07 ⁱ
H ₂ S ₅	6.85 ^d	6.56 ^{cd}	7.83 ^d	6.89 ^{cd}	3.81 ^c	4.01 ^{cd}
LSD = 0.05	0.04*	0.2*	0.03*	0.28*	0.073*	0.072*

Mean values in column not comprising same letter vary significantly at P = 0.05; * = Significant at 5% level.

sources) was highly significant for grain yield (t ha⁻¹) and S₃ VS S₅ contrast comparison for grain yield (t ha⁻¹) was found to be non significant.

Quality parameter

Grain protein content (%)

Hybrid maize significantly affected grain protein content for both year 2008 and 2009. Data reveal that maximum grain protein content was found in H₁ (7.06%) and (6.88%) in 2008 and 2009, respectively as to compared to H₂ (6.92) and (6.34%) as shown in Table 1. These results corroborate the findings of UribeLarra et al. (2004).

The effect of nitrogen sources on grain protein content was also significant in both seasons. Nitrogen sources S₁ (8.25%) and (8.09%) produced maximum grain protein content and minimum grain protein content noted in S₀ (4.71%) and (4.09%), respectively in 2008 and 2009. Enhancement in grain protein was due to availability of

nitrogen to plant at proper time and in proper proportion. These results are similar to the findings of UribeLarra et al. (2004).

A significant interactive effect of maize hybrids and integrated nitrogen sources was observed during both years. Maximum grain protein content was recorded in H₁S₁ (8.33%) treatment combination while minimum grain protein content was found in H₁S₀ (4.81%). Similar trend of interaction was recorded in 2009. These results corroborate the findings of UribeLarra et al. (2004).

In year 2008, contrasts comparison (Table 2) between H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was highly significant for grain protein content (%). Contrast comparison during 2009 among H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅ was highly significant for grain protein content (%) except contrast for S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources), S₄ VS S₅ on grain protein content (%) was found to be non significant.

Table 2. Contrast comparisons of hybrid maize and integrated nitrogen sources for grain yield, grain protein content and grain oil content attributes in 2008-2009.

Treat	Grain yield		Grain protein content (%)		Grain oil content (%)	
	2008	2009	2008	2009	2008	2009
H ₁ VS H ₂	**	**	**	**	**	**
S ₀ VS S ₁ ,S ₂ ,S ₃ ,S ₄ ,S ₅	N.S	**	**	N.S	**	*
S ₁ VS S ₂	**	**	**	**	**	**
S ₁ VS S ₃	**	**	**	**	**	**
S ₁ VS S ₄	**	**	**	**	**	**
S ₁ VS S ₅	**	**	**	**	**	**
S ₂ VS S ₃	**	**	**	**	**	**
S ₂ VS S ₄	**	**	**	**	**	**
S ₂ VS S ₅	**	**	**	**	**	**
S ₃ VS S ₄	**	**	**	**	**	**
S ₃ VS S ₅	N.S	N.S	**	**	**	**
S ₄ VS S ₅	**	**	**	N.S	**	N.S

H₁ : Pioneer-30Y87, H₂ : Pioneer-31R88, S₀ : (Control), S₁ : Urea (50%) + Poultry manure (50%), S₂ : Urea (50%) + Farm Yard Manure (50%), S₃ : Urea (50%) + Press mud of sugarcane (50%), S₄ : Urea (50%) + Compost (50%), S₅ : Urea (50%) +(PM + FYM + PMS + Compost) 50% Mean values in column not comprising same letter vary significantly at P=0.05, *=Significant at 5% level, **=highly Significant at 5% level, N.S = Non significant.

Grain oil content (%)

Hybrid maize significantly influenced grain oil content during 2008 and 2009. Data in Table 1 showed that hybrid H₁ produced significantly maximum (3.44%) and (3.79%) grain oil content as compared to hybrid H₂ (3.63%) and (3.38%) during 2008 and 2009, respectively. While in 2008, trends of oil content were less because there was more protein in 2008. These results corroborate the findings of Rasheed et al. (2004).

The effect of nitrogen sources on grain oil content was also significant in both seasons. In 2009, nitrogen sources S₁ produced maximum (4.09%) and (4.39%) grain oil content in 2008 and 2009 and minimum grain oil content was noted in S₀ (2.25%) and (3.08%). Grain oil content trends of year 2008 were identical with year 2009. Low grain oil content in 2008 was due to availability of nitrogen to plant at proper time and in proper proportion because if protein content is more, then oil content is decreases. These results narrate the findings of Witt and Pasuquin (2007b).

A significant interactive effect of maize hybrids and integrated nitrogen sources was observed during both year 2008 and 2009. In 2009 maximum grain oil content was recorded in H₁S₁ (4.57%) treatment combination while minimum was found in H₂S₀ (2.99%). A similar trend of interaction recorded in year 2008 was similar with 2009. These results lend support to the findings of Witt and Pasuquin (2007b).

In year 2008, contrasts comparison (Table 2) between H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was highly significant for grain oil content (%). Contrast

comparison during 2009 among S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was significant for grain oil content (%) while H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅ contrast comparison was also observed to be highly significant for grain oil content (%) except contrast for S₄ VS S₅ on grain oil content (%) was found to be non significant.

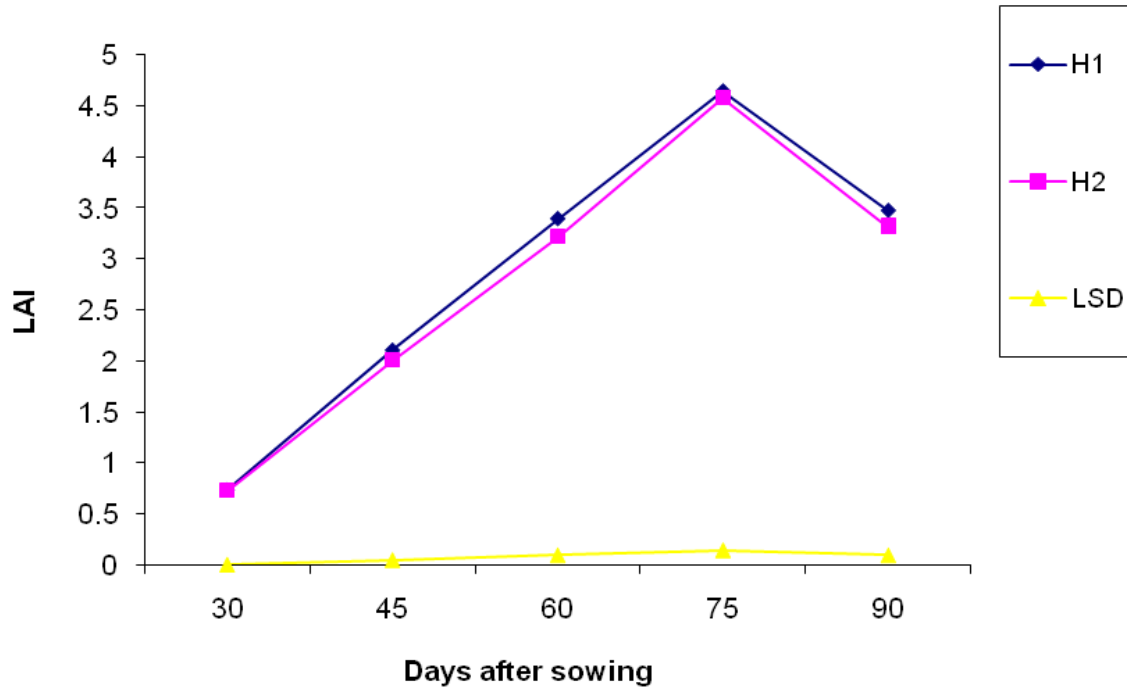
Growth

Leaf area index (75 DAS)

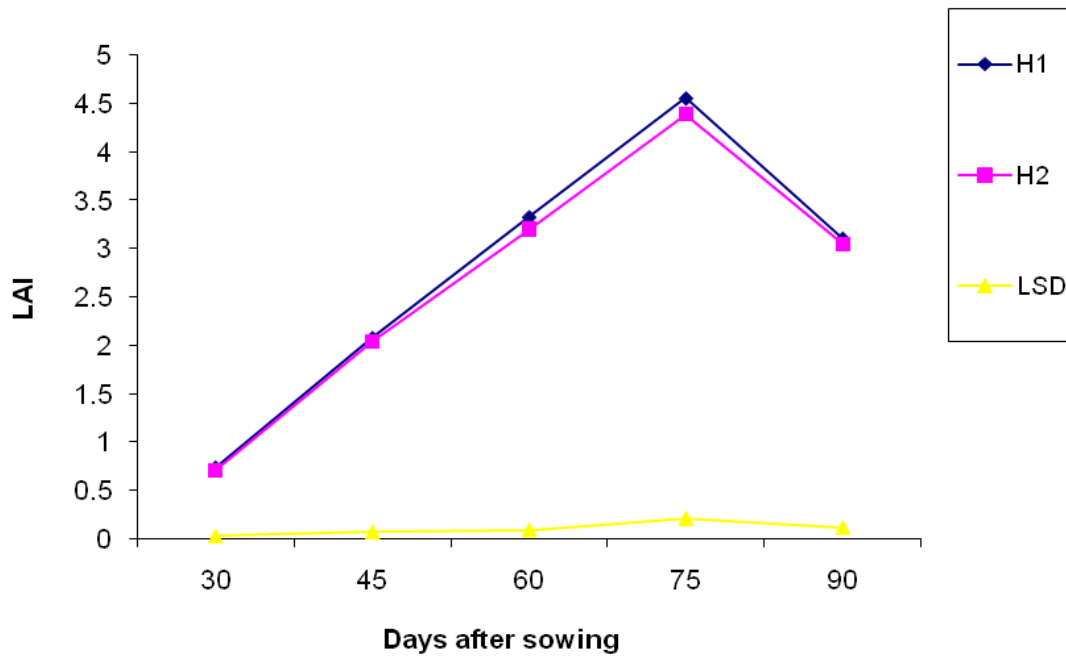
Figure 1(a) clearly shows how leaf area index increased and decreased with the passage of time. First, 30 to 75 DAS leaf area index increased and then after 75 DAS, it start to decreased till maturity as influenced by both hybrid and different integrated nitrogen sources. In 2008, maximum LAI recorded in hybrid H₁ (Pioneer-30Y87) at 75 DAS and minimum LAI was noted in hybrid H₂ (Pioneer). After 75 DAS LAI moves towards decreasing till harvest. In 2009, similar trends regarding LAI in hybrids were found as shown in Figure 1(b).

Effect of different integrated nitrogen sources on LAI was also significant in both seasons. In 2008, maximum LAI was documented in nitrogen sources S₁ and minimum LAI was noted in S₀ as shown in Figure 2(a). In all nitrogen sources, LAI goes to high value with increasing of days in sowing. Figure 2(b) in 2009 also showed similar trends of increasing LAI.

Hybrid maize significantly affected leaf area index (LAI) during 2008 and 2009. In 2008, maximum (4.65) LAI was noted in hybrid H₁ (Pioneer-30Y87) at 75 DAS and



A

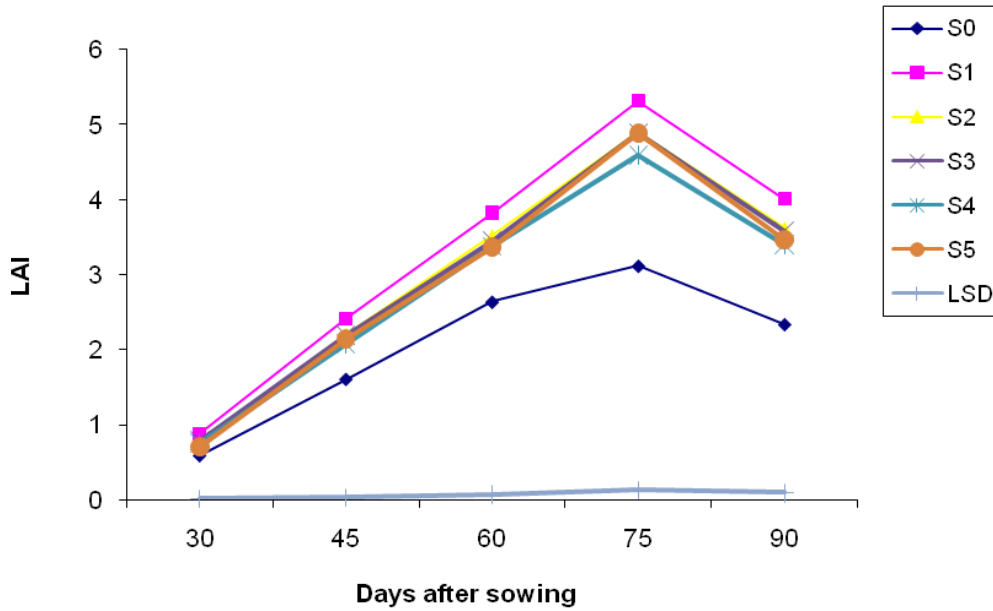


B

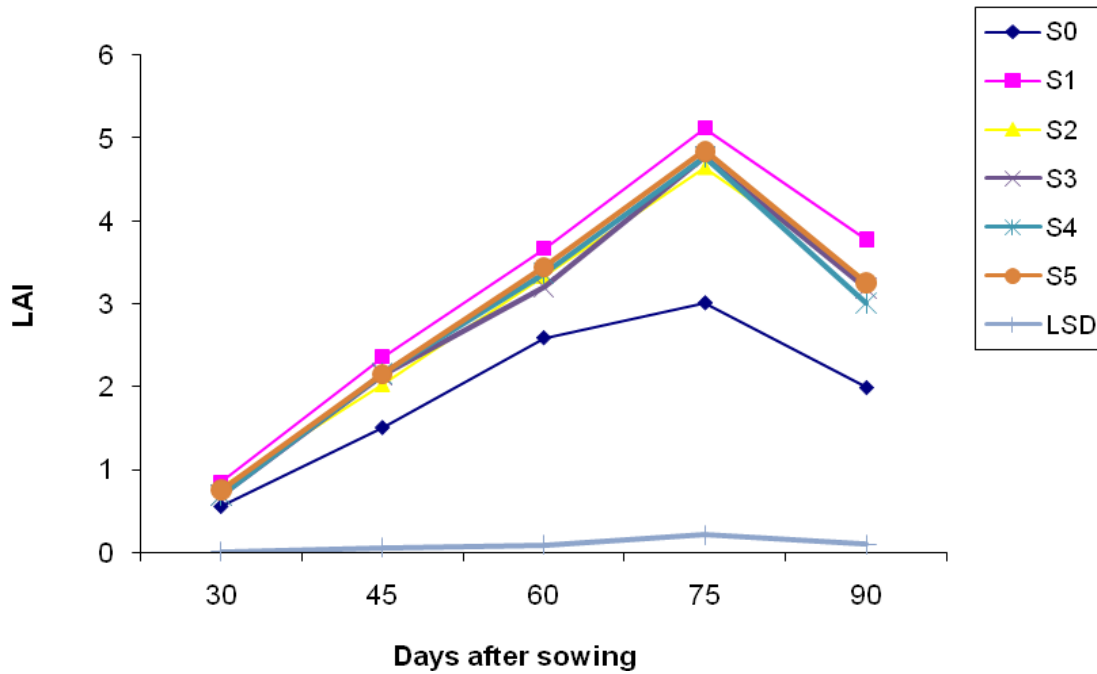
Figure 1(a). Periodic LAI development as influenced by hybrid maize during 2008. **(b).** Periodic LAI development as influenced by hybrid maize during 2009.

minimum (4.58) was observed in hybrid H₂ (Pioneer-31R88). Trends of (LAI) of hybrids maize in 2009 was significant and at par with 2008. Similar results were repeated by Kumar and Walia (2003).

As for data concerning the effect of nitrogen sources on (LAI), development trend to be significant in both seasons. In 2008, (LAI) of nitrogen sources was maximum in nitrogen sources S₁ (5.31) and minimum LAI in nitrogen



A



B

Figure 2(a). Periodic LAI development as influenced by nitrogen sources during 2008. **(b).** Periodic LAI development as influenced by nitrogen sources during 2009.

source S₀ (3.12) as shown in Table 3. Similar increasing and decreasing trends of (LAI) was observed in nitrogen sources in 2009 which was statically at par with 2008. (LAI) increases gradually and reached its maximum value at 75 DAS and after that it decreased. These results

confirmed the findings of Kumar and Walia (2003) and Kumar and Sundari (2002).

A significant interactive effect of maize hybrids and nitrogen sources was observed during both years. In 2008, (LAI) was maximum in interaction of H₁S₁ (5.33)

Table 3. Influence of different nitrogen sources on various growth traits of hybrid maize during 2008-2009.

Treat	LAI 75DAS		LAD 75-90DAS		DMA 90DAS		CGR		NAR	
Year	2008	2008	2008	2009	2008	2009	2008	2009	2008	2009
A-Hybrids										
H ₁	4.65 ^a	4.56 ^a	184.40 ^a	178.88 ^a	1416.3 ^a	1347.7 ^a	20.20 ^a	19.01 ^a	7.64 ^a	7.49
H ₂	4.58 ^b	4.49 ^b	180.88 ^b	174.40 ^b	1347.1 ^b	1309.5 ^b	19.08 ^b	18.51 ^b	7.04 ^b	7.47
LSD	0.014*	0.012*	0.59*	0.41*	1.91*	6.49*	0.04*	0.11*	0.26*	N.S
B-Nitrogen Sources										
S ₀	3.12 ^d	3.01 ^e	132.84 ^e	126.04 ^e	915.7 ^f	863.8 ^e	12.74 ^f	11.98 ^e	6.89 ^f	6.85 ^d
S ₁	5.31 ^a	5.12 ^a	210.03 ^a	202.15 ^a	1651.0 ^a	1591.0 ^a	23.62 ^a	22.79 ^a	7.86 ^a	7.87 ^a
S ₂	4.90 ^b	4.64 ^d	191.84 ^b	180.73 ^d	1424.1 ^c	1377.5 ^c	20.13 ^c	19.48 ^c	7.41 ^e	7.62 ^b
S ₃	4.89 ^b	4.77 ^c	191.20 ^b	180.99 ^d	1490.3 ^b	1384.0 ^c	21.35 ^b	19.52 ^c	7.79 ^b	7.64 ^b
S ₄	4.60 ^c	4.78 ^c	182.23 ^d	182.63 ^c	1402.5 ^e	1355.4 ^d	19.94 ^e	19.03 ^d	7.69 ^c	7.42 ^c
S ₅	4.89 ^b	4.85 ^b	187.73 ^c	187.28 ^b	1407.0 ^d	1399.8 ^b	20.05 ^d	19.77 ^b	7.49 ^d	7.47 ^c
LSD	0.03*	0.021*	1.04*	0.71*	3.29*	11.24*	0.07*	0.19*	0.05*	0.07*
C-Interaction (H x NS)										
H ₁ S ₀	3.07 ^l	3.04 ^j	131.25 ^j	128.25 ^h	926.5 ^k	873.1 ^h	13.02 ^k	12.01 ^h	7.05 ^f	6.80 ^h
H ₁ S ₁	5.33 ^a	5.17 ^a	210.95 ^a	204.12 ^a	1657.5 ^a	1606.2 ^a	23.74 ^a	22.94 ^a	7.85 ^a	7.86 ^a
H ₁ S ₂	5.10 ^c	4.67 ^g	196.10 ^c	182.22 ^e	1505.1 ^d	1421.2 ^d	21.46 ^d	20.12 ^d	7.67 ^b	7.79 ^{ab}
H ₁ S ₃	4.97 ^d	4.75 ^f	192.80 ^d	178.92 ^f	1513.3 ^c	1380.7 ^e	21.62 ^c	19.52 ^e	7.84 ^a	7.72 ^{bc}
H ₁ S ₄	4.55 ^j	4.97 ^c	183.90 ^g	188.10 ^d	1452.6 ^f	1356.3 ^f	20.81 ^f	18.95 ^g	7.90 ^a	7.21 ^f
H ₁ S ₅	4.91 ^e	4.81 ^e	191.40 ^d	191.55 ^c	1443.0 ^g	1448.4 ^c	20.55 ^g	20.54 ^c	7.53 ^c	7.56 ^d
H ₂ S ₀	3.18 ^k	2.99 ^k	134.42 ^j	123.80 ^j	904.8 ^l	854.51 ⁱ	12.45 ^l	11.94 ^h	6.73 ^g	6.90 ^g
H ₂ S ₁	5.29 ^b	5.07 ^b	209.10 ^b	200.18 ^b	1644.4 ^b	1575.8 ^b	23.49 ^b	22.63 ^b	7.86 ^a	7.87 ^a
H ₂ S ₂	4.71 ^h	4.62 ^h	187.57 ^f	179.23 ^f	1343.0 ^j	1333.7 ^g	18.18 ^j	18.84 ^g	7.15 ^e	7.44 ^e
H ₂ S ₃	4.81 ^g	4.79 ^e	189.60 ^e	183.05 ^e	1467.3 ^e	1387.2 ^e	21.09 ^e	19.54 ^e	7.73 ^b	7.57 ^d
H ₂ S ₄	4.65 ⁱ	4.59 ⁱ	180.55 ^h	177.15 ^g	1352.3 ⁱ	1354.5 ^f	19.07 ⁱ	19.12 ^f	7.49 ^{cd}	7.64 ^{cd}
H ₂ S ₅	4.87 ^f	4.89 ^d	184.05 ^g	183.0 ^e	1371.0 ^h	1351.2 ^f	19.56 ^h	19.00 ^g	7.44 ^d	7.38 ^e
LSD	0.03*	0.02*	1.46*	0.99*	4.66*	15.90*	0.09*	0.27*	0.06*	0.09*

LAI, Leaf area index; LAD, leaf area duration; DMA, dry matter accumulation; CGR, crop growth rate; NAR, net assimilation rate. Mean values in column not comprising same letter vary significantly at P=0.05, *=Significant at 5% level, N.S = Non significant.

treatment combination and while minimum leaf area index was found in H₁S₀ (3.27). Interactive trends of (LAI) during 2009 were also similar with year 2008. The increase in leaf area index might be due to the availability of nitrogen to the crop at proper time in inorganic treatments and slow release of nutrients from the organic sources throughout the growing season. These results corroborate the findings Kumar and Walia (2003) and Kumar and Sundari (2002).

During 2008, contrasts comparison between H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₄, S₃ VS S₄, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was highly significant for leaf area index at 75 DAS (Table 4) while non significant contrast comparison was observed for leaf area index at 75 DAS of S₂ VS S₃, S₂ VS S₅, S₃ VS S₅, leaf area index at 75 DAS. Contrast comparison during 2009 among H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄,

S₅ (nitrogen sources) was found to be highly significant for leaf area index at 75 DAS (Table 4) and non significant contrast comparisons was observed in S₃ VS S₄, leaf area index at 75 DAS.

Leaf area duration (75 to 90)

Hybrid maize was significantly influenced by leaf area duration during 2008 and 2009. Data in Table 3 showed that at 75 to 90 DAS in 2008 maximum (184.40) LAD at (75 to 90 DAS) noted in hybrid H₁ and minimum (180.88). LAD was noted in hybrid H₂ (Pioneer-30Y88). Increased in leaf area duration at (75 to 90 DAS) 2009 was similar with year 2008. These results are in line with the findings of Akbar et al. (2002).

Data concerning about the effect of nitrogen sources was also significant in both season. In 2008, nitrogen source S₁ (210.03) produced maximum (210.03) leaf area

Table 4. Contrast comparisons of hybrid maize and integrated nitrogen sources for different growth attributes during 2008-2009.

Treat	LAI 75DAS		LAD 75-90DAS		DMA 90DAS		CGR		NAR	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
H ₁ VS H ₂	**	**	N.S	**	**	**	**	N.S	**	**
S ₀ VS S ₁ ,S ₂ ,S ₃ ,S ₄ ,S ₅	**	**	N.S	**	**	*	**	*	**	**
S ₁ VS S ₂	**	**	**	**	**	**	**	**	**	**
S ₁ VS S ₃	**	**	**	**	**	**	**	**	*	**
S ₁ VS S ₄	**	**	**	**	**	**	**	**	**	**
S ₁ VS S ₅	**	**	**	**	**	**	**	**	**	**
S ₂ VS S ₃	N.S	**	N.S	**	**	N.S	**	N.S	**	N.S
S ₂ VS S ₄	**	**	**	**	**	**	**	N.S	**	**
S ₂ VS S ₅	N.S	**	**	**	**	**	N.S	N.S	*	**
S ₃ VS S ₄	**	N.S	**	**	**	**	**	N.S	N.S	**
S ₃ VS S ₅	N.S	**	*	**	**	**	**	N.S	*	**
S ₄ VS S ₅	**	**	N.S	**	**	**	**	N.S	N.S	**

H₁ : Pioneer-30Y87, H₂ : Pioneer-31R88, S₀ : (Control), S₁ : Urea (50%)+Poultry manure (50%), S₂ : Urea (50%)+Farm Yard Manure (50%), S₃ : Urea (50%)+Pressmud of sugarcane (50%), S₄ : Urea (50%)+Compost (50%), S₅ : Urea (50%)+(PM+FYM+PMS+Compost) 50%. LAI, Leaf area index; LAD, leaf area duration; DMA, dry matter accumulation; CGR, crop growth rate; NAR, net assimilation rate. Mean values in column not comprising same letter vary significantly at P=0.05, *=Significant at 5% level, **=highly Significant at 5% level, N.S = Non significant.

duration and minimum leaf area duration was found in S₀ (132.84). Progress in leaf area duration 2009 was statistically at par with first year 2008. Enhancement in leaf area duration was due to availability of nitrogen to plant at proper time and in proper proportion. These results are providing support to the findings of Akbar et al. (2002), Kumar and Walia (2003), Kumar and Sundari (2002).

Significant interactive effects of maize hybrids and nitrogen sources were observed during both years. In 2008 maximum leaf area duration was recorded in H₁S₁ (210.95) treatment combination and minimum was found in H₁S₀ (131.25). Similar trends of interactive effect regarding LAD were observed in year 2009. These results concise with the finding of Akbar et al. (2002), Kumar and Walia (2003), Kumar and Sundari (2002).

Figures 5(a and b) shows a regression between LAD and DM which was positive and significant during both seasons. Regression accounted line for LAD and DM was 0.98 and 0.99 during 2008 and 2009. It is clear from the Figure 5, if LAD increased then dry matter was also increased.

For measuring the degree of linear association, a simple linear regression used between grain yield and LAD was significant and positive during both years (Figures 3 (a and b)).Both grain yield and LAD was interpedently and directly related with regression accounted for 0.980 and 0.960 during 2008 and 2009. It is clear from the figure that if LAD increased then there was concurrent increase in grain yield.

In 2008 contrasts, comparison between S₃ VS S₅ was significant for leaf area duration (75 to 90 DAS) (Table 4) and S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄ contrast comparison was also observed

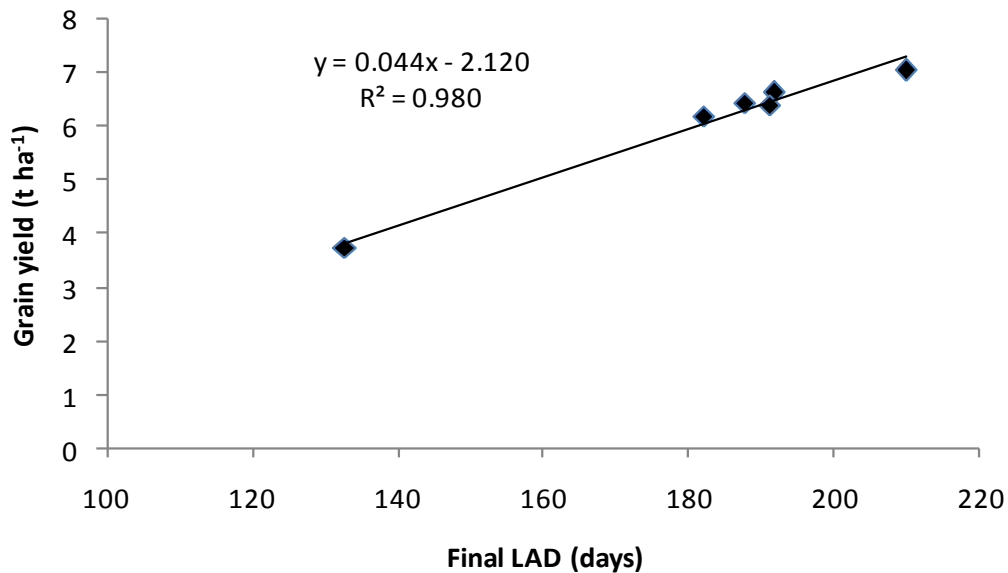
to be highly significant for leaf area duration (75 to 90 DAS) while non significant contrast comparison was observed for leaf area duration (75 to 90 DAS) of H₁ vs H₂, S₂ VS S₃, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources). Contrast comparison during 2009 among H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was found to be highly significant for leaf area duration (75 to 90 DAS).

Dry matter accumulation (90 DAS)

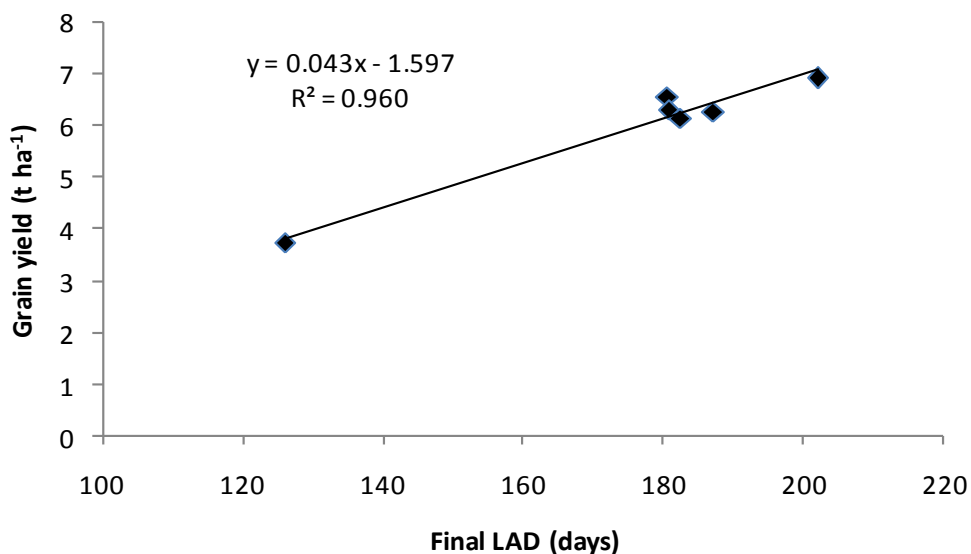
Hybrid maize significantly influenced dry matter accumulation (DMA) during 2008 and 2009 as shown in Figure 6 (a and b). Dry matter accumulation increased from sowing to maturity with maximum dry matter accumulation found in hybrid H₁ (Pioneer-30Y87) and minimum dry matter accumulation was recorded in hybrid H₂ (Pioneer-31R88). Dry matter accumulation trends of year 2009 were statistically at par with year 2008. These results are in agreement with the findings of Shapiro and Wortmann (2006).

Figure 7 (a and b) clearly shows that the temporal increase of dry matter accumulation increased with passage of time till maturity as influenced by different nitrogen sources. Maximum dry matter accumulation was recorded in nitrogen sources S₁ and minimum dry matter accumulation was noted in S₀. Similar trends of dry matter accumulation were observed in 2009.

Data in Table 3 showed that dry matter accumulation significantly influenced hybrid maize during both seasons. In 2008, maximum (1416.3 g m⁻²) dry matter accumulation



A



B

Figure 3(a). Relationship between grain yield and leaf area duration during 2008. **(b).** Relationship between grain yield and leaf area duration during 2009.

was recorded in hybrid H₁ (Pioneer-30Y88) at 90 DAS and minimum (1341.3 g m⁻²) dry matter accumulation was noted in hybrid H₂ (Pioneer-31R88) at 90DAS. Trends of dry matter accumulation in 2009 were statistically similar with 2008.

An integrated nitrogen source was also significantly affected dry matter accumulation in both seasons. In 2008, dry matter accumulation increased consequently

and nitrogen sources S₁ (1651.0 g m⁻²) produced maximum dry matter accumulation and minimum dry matter accumulation was noted in S₀ (915.7 g m⁻²). Dry matter accumulation trend during year 2009 is entirely same with year 2008. Enhancement in dry matter accumulation was due to availability of nitrogen to plant at proper time and in proper proportion. These results are very closely related with those of Sharar et al. (2003).

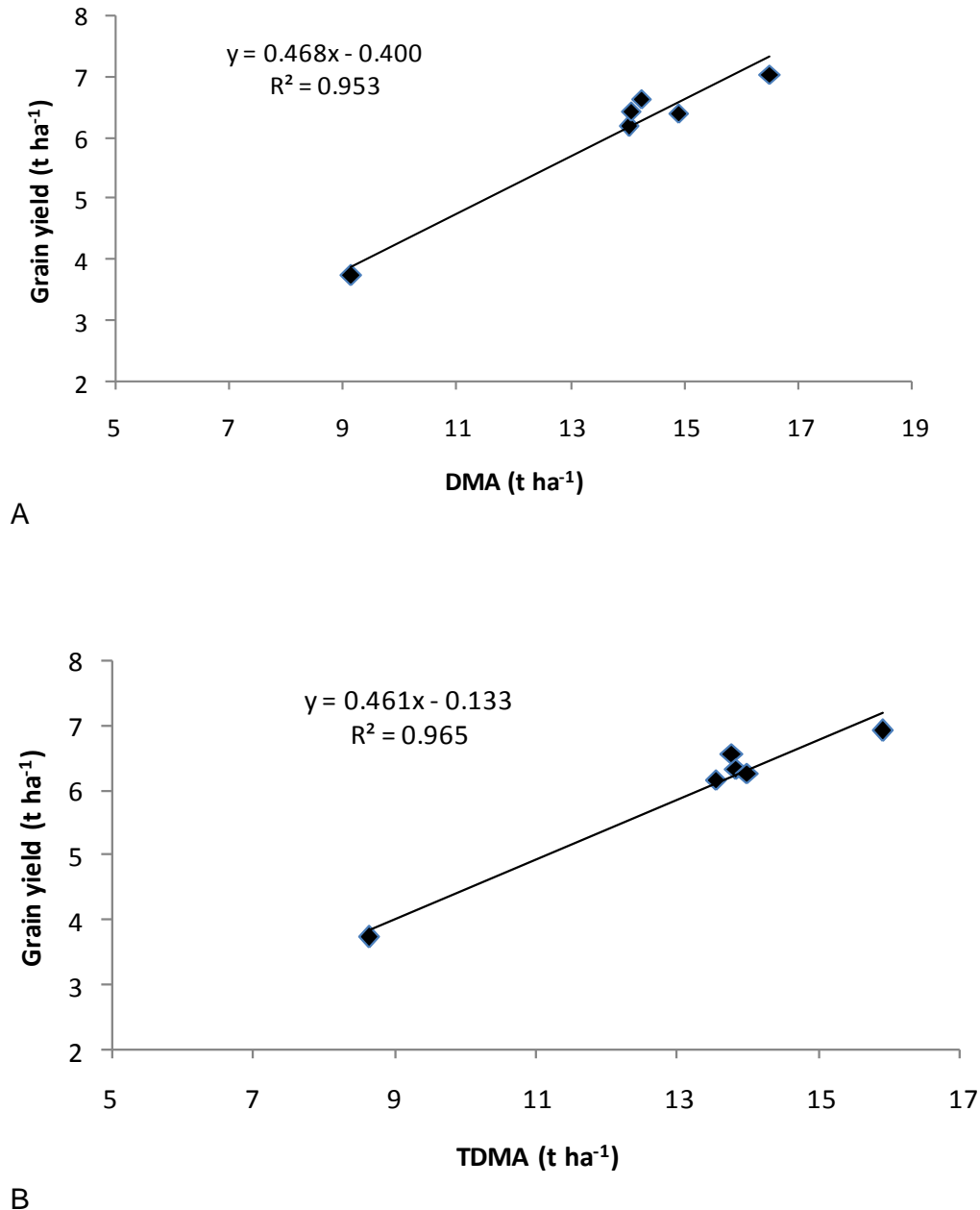


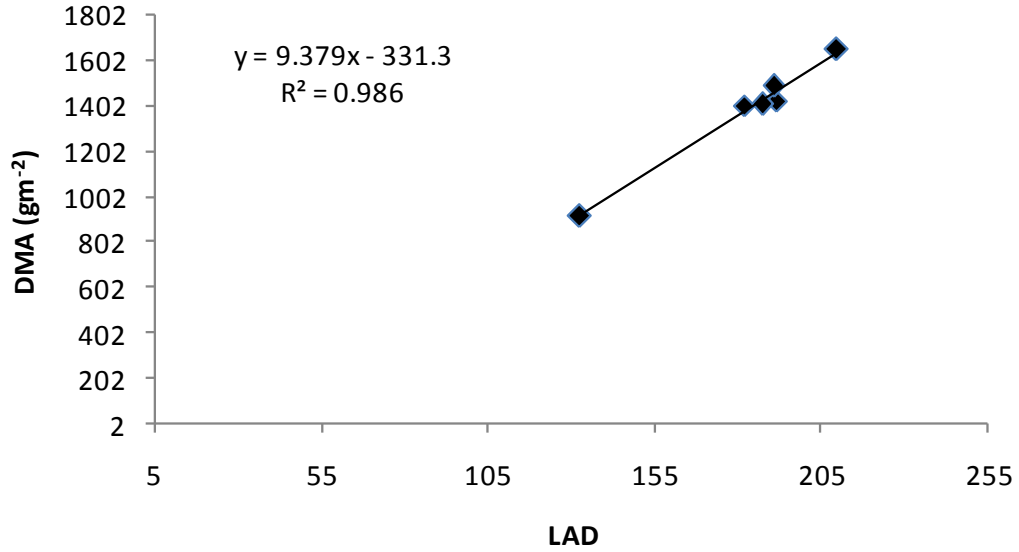
Figure 4(a). Relationship between grain yield and dry matter accumulation during 2008. **(b).** Relationship between grain yield and dry matter accumulation during 2009.

Significant interactive effects of maize hybrids and nitrogen sources were observed during both years. In 2008, maximum dry matter accumulation was recorded in H_1S_1 ($1657.5\ g\ m^{-2}$) treatment combination while minimum dry matter accumulation was found in interaction of H_1S_0 ($904.8\ g\ m^{-2}$). Similar trends regarding dry matter accumulation were observed in 2009. These results confirm the conclusion of Shapiro and Wortmann (2006).

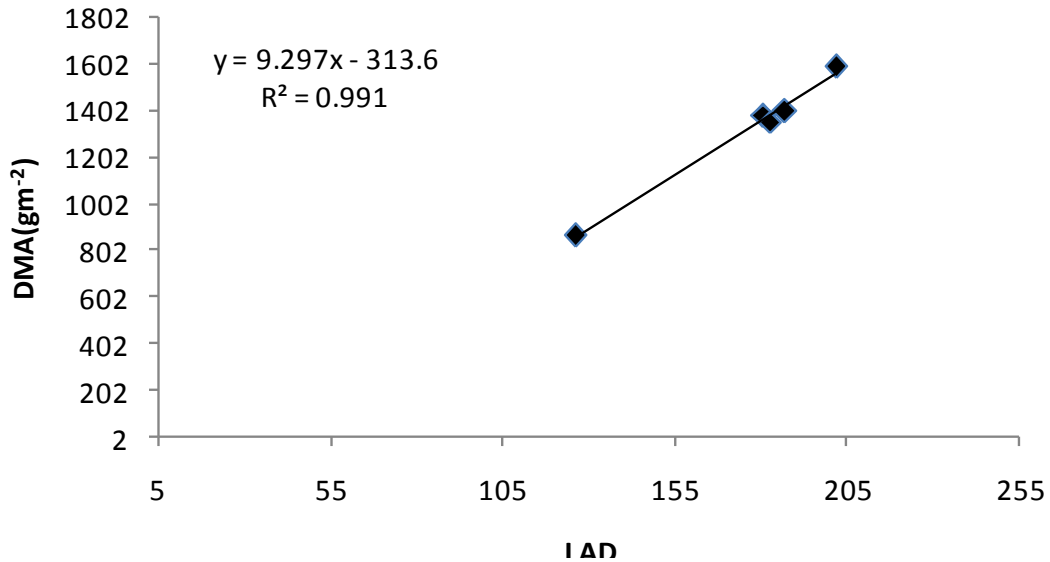
In both years, 2008 and 2009, contrasts comparison between H_1 vs H_2 , S_1 VS S_2 , S_1 VS S_3 , S_1 VS S_4 , S_1 VS S_5 , S_2 VS S_3 , S_2 VS S_4 , S_2 VS S_5 , S_3 VS S_4 , S_3 VS S_5 , S_4 VS

S_5 , S_0 (Control) vs S_1 , S_2 , S_3 , S_4 , S_5 (nitrogen sources) was highly significant for dry matter accumulation at 90 DAS (Table 4) except in 2009 contrasts comparison among S_2 VS S_3 was non significant for dry matter accumulation at 90 DAS.

A simple linear correlation use between grain yield and DMA which was significant and positive during both years as shown in Figure 4(a and b). Both grain yield and DMA was interpedently and directly related with regression line accounted 0.953 and 0.965 during 2008 and 2009. It is clear from the figure if DMA increased then there was



A



B

Figure 5(a). Relationship between leaf area duration (LAD) and dry matter accumulation (DMA) during 2008. **(b).** Relationship between leaf area duration (LAD) and dry matter accumulation (DMA) during 2009.

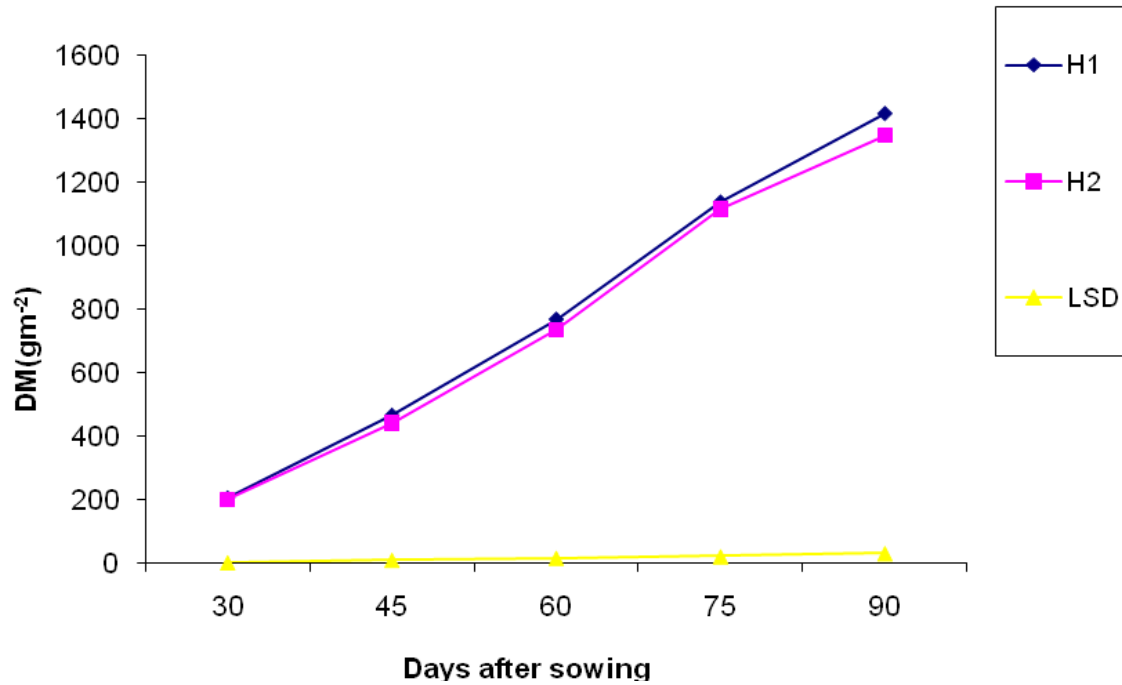
increase in grain yield.

Mean crop growth rate (g m⁻² d⁻¹)

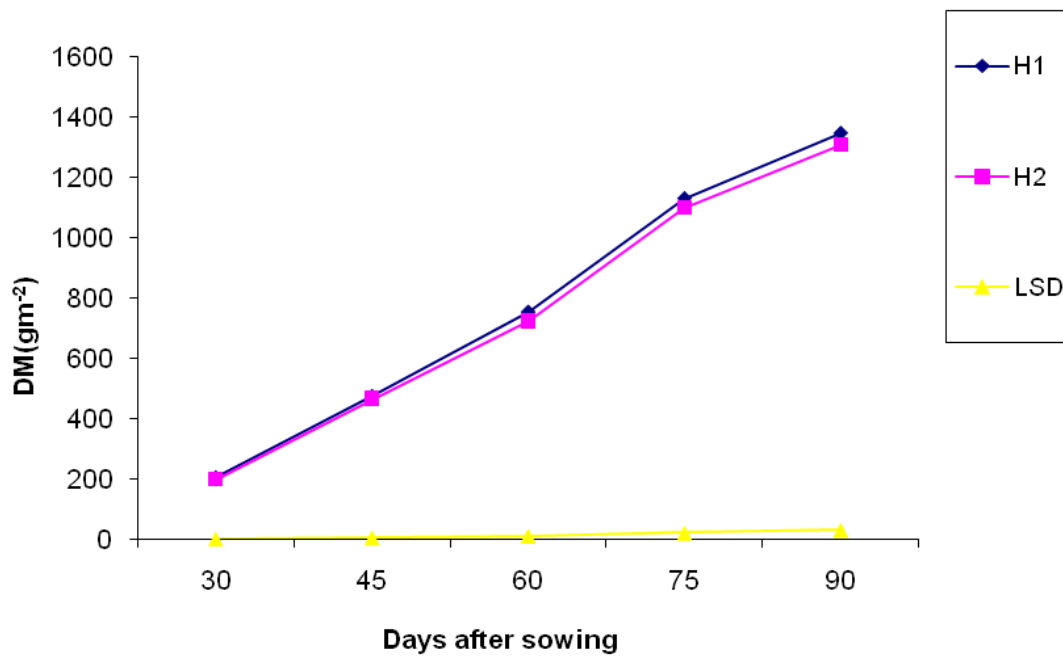
Table 3 shows that hybrid maize significantly affected the crop growth rate (CGR) during 2008 and 2009. Maximum

crop growth rate was produced by hybrid H₁ (20.37 g m⁻² d⁻¹) as compared to hybrid H₂ (19.08 g m⁻² d⁻¹) during 2008. Crop growth rate trend of both hybrids during 2009 was statistically at par with 2008. These results confirm the findings of Okeleye and Oyekanmi (2003) who also reported similar values of CGR.

The effect of nitrogen sources on crop growth rate was



A

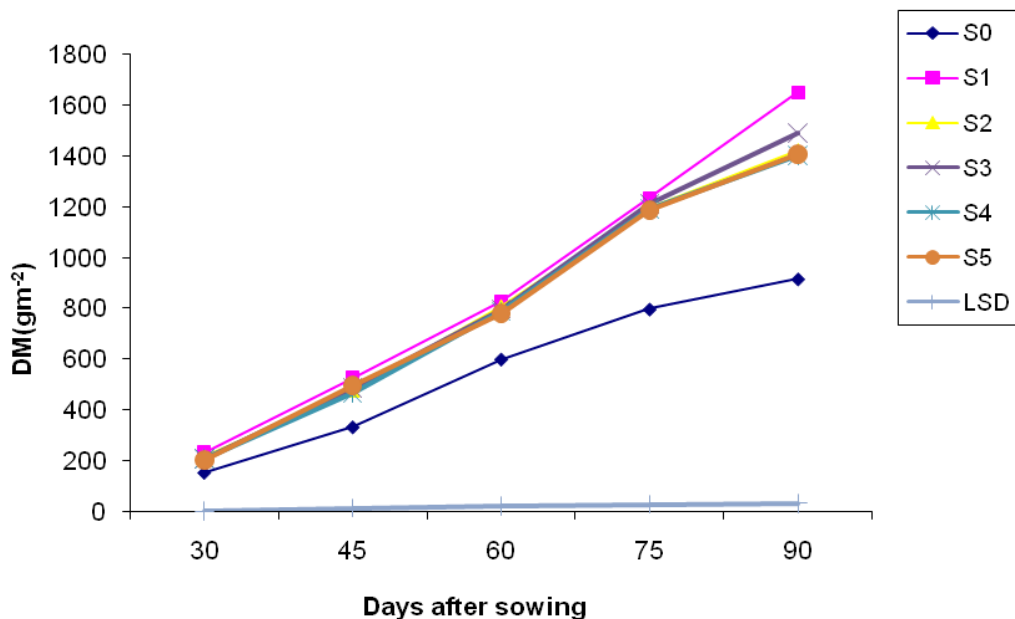


B

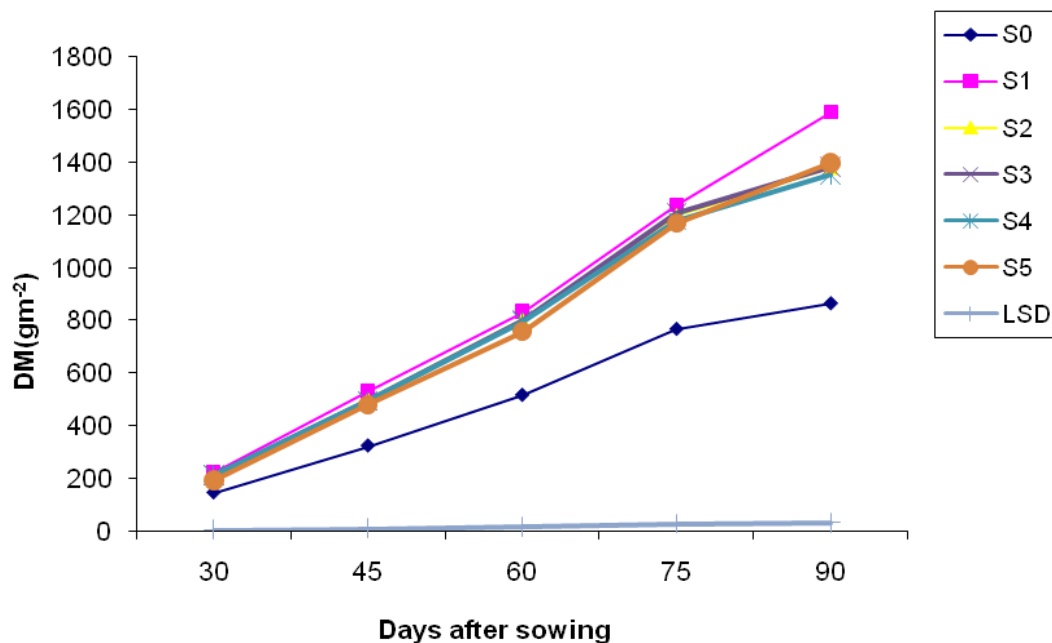
Figure 6(a). Periodic dry matter accumulation (gm⁻²) as influenced by hybrid maize during 2008. **(b).** Periodic dry matter accumulation (gm⁻²) as influenced by hybrid maize during 2009.

also significant in both seasons. Nitrogen source S₁ (23.62 g m⁻² d⁻¹) and (22.79 g m⁻² d⁻¹) in 2008 and 2009, respectively produced maximum crop growth rate and

minimum crop growth rate was noted in S₀ (12.74 g m⁻² d⁻¹) and (11.98 g m⁻² d⁻¹). Enhancement in crop growth rate was due to availability of nitrogen to plant at proper time



A



B

Figure 7(a). Periodic dry matter accumulation (gm^{-2}) as influenced by nitrogen sources during 2008. **(b).** Periodic dry matter accumulation (gm^{-2}) as influenced by nitrogen sources during 2009.

and in proper proportion. These results are supportive to the findings of Evans et al. (2003).

Significant interactive effects between maize hybrids and nitrogen sources were observed during both years. Maximum crop growth rate was recorded in interaction of hybrid H₁ and nitrogen sources H₁S₁ ($23.74 \text{ g m}^{-2} \text{ d}^{-1}$)

while minimum was found in interaction of H₁S₀ ($13.02 \text{ g m}^{-2} \text{ d}^{-1}$). Similar trends of interactive effects on crop growth rate were found in 2009. Evans et al. (2003) also noted similar interactive effects of hybrid and N sources in maize.

In year 2008, contrasts comparison (Table 4) between

H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was highly significant for crop growth rate (g m⁻² d⁻¹) except contrasts comparison among S₂ VS S₅ was non significant for crop growth rate (g m⁻² d⁻¹). As for contrast comparison during 2009 among S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was significant for crop growth rate (g m⁻² d⁻¹). Contrast for S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅ on crop growth rate (g m⁻² d⁻¹) was found to be highly significant while H₁ vs H₂, S₂ VS S₃, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, contrast comparison was also observed to be non significant for crop growth rate (g m⁻² d⁻¹).

Mean net assimilation rate (g m⁻² d⁻¹)

Hybrid maize showed a significant influence on net assimilation rate (NAR) during 2008 and 2009. Results in Table 3 showed that maximum net assimilation rate was concluded by hybrid H₁ (7.64 g m⁻² d⁻¹) as compared to H₂ (7.04 g m⁻² d⁻¹) during 2008. Trend of net assimilation rate of 2009 was similar with 2008. These results confirmed the findings of Ahmad et al. (1993), Randawa et al. (2002) and Akbar et al. (2002).

The effect of nitrogen sources net assimilation rate was also significant in both seasons. Nitrogen sources S₁ (7.86 g m⁻² d⁻¹) produced maximum net assimilation rate and minimum net assimilation rate was noted in S₀ (6.89 g m⁻² d⁻¹). Net assimilation rate trends of year 2009 were at par with year 2008. Enhancement in net assimilation rate was due to availability of nitrogen to plant at proper time and in proper proportion. These results are closely related with those of Ahmad et al. (1993) and Randawa et al. (2002).

A significant interactive effect of maize hybrids and nitrogen sources was observed during both year. Maximum net assimilation rate of interactive effects of H₁S₁, H₂S₁ (8.16 g m⁻² d⁻¹) was recorded and minimum was found in interaction of H₂S₀ (6.73 g m⁻² d⁻¹). Similar trends of interaction recorded in 2009. These results complement the finding of Ahmad et al. (1993), Randawa et al. (2002) and Evans et al. (2003).

In year 2008, contrasts comparison (Table 4) between S₁ VS S₃, S₂ VS S₅, S₃ VS S₅ was significant for net assimilation rate (g m⁻² d⁻¹) and contrast for H₁ vs H₂, S₁ VS S₂, S₁ VS S₄, S₁ VS S₅, S₂ VS S₃, S₂ VS S₄, S₀(Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) on net assimilation rate (g m⁻² d⁻¹) was found to be significant except contrasts comparison among S₃ VS S₄, S₄ VS S₅, was non significant for net assimilation rate (g m⁻² d⁻¹). As for contrast comparison during 2009 among H₁ vs H₂, S₁ VS S₂, S₁ VS S₃, S₁ VS S₄, S₁ VS S₅, S₂ VS S₄, S₂ VS S₅, S₃ VS S₄, S₃ VS S₅, S₄ VS S₅, S₀ (Control) vs S₁, S₂, S₃, S₄, S₅ (nitrogen sources) was highly significant for net assimilation rate (g m⁻² d⁻¹) except contrast for S₂ VS S₃

on net assimilation rate (g m⁻² d⁻¹) was found to be non significant.

Conclusion

On the basis of results, it was concluded that hybrid maize H₁ (Pioneer 30Y87) produced better grain yield (7.05 t ha⁻¹) during 2008 when nitrogen sources S₁: Urea (50%) + Poultry manure (50%) was applied in combination as compared to grain yield (6.92 t ha⁻¹) in hybrid H₂ (Pioneer 31R88) during 2009. Growth and quality attributes was also performed better in hybrid maize H₁ (Pioneer 30Y87) during 2008 as compared to 2009 at nitrogen sources S₁: Urea (50%) + Poultry manure (50%).

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