International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Leaf Number Index: A Ready Reckoner to Identify the Reproductive Stage for Nutrition of Six Maize (Zea Mays L.) Hybrids

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Abstract

Field experiments were carried to study the leaf number index of maize hybrids to identify the reproductive stage of six maize hybrids for application of nutrition at suitable time to improve more production was under taken at the Agricultural College farm, Bapatla during two consecutive years during *rabi* 2016-17 and 2017-18. The experiment was laid out in randomized block design with six maize hybrids as treatments in four replications. During both the seasons, tassel primordial initiation coincide with the 9th visible leaf in 900 M Gold and DKC 9081, 10th visible leaf in DKC 9142 and Pinnacle and 11th visible leaf in DKC 9120 and DKC 9042 with LNI of 54.54, 54.54, 53.77, 52.79, 54.62 and 54.62 respectively in first season and 53.70, 54.71, 51.85, 53.70, 55.55 and 54.71 respectively in second season.

Keywords: Leaf number Index, Reproductive stage , Nutrition

Introduction

Maize is the world's third most important cereal crop after wheat and rice. The maize production in India about 22 million tonnes with an area of 9.2 million hectare. Several experiments were conducted to determine the growth stages of maize in a given environment. But, the basis for the variation in dry matter production and reproductive growth in relation to its foliage is less understood. The leaf growth that designates the physiological age of crop is more useful for crop improvement programmes.

Leaf development, represented by the appearance and accumulation of leaves is an important part of the vegetative development of agricultural crops. In maize, leaf development starts at emergence and ends with the appearance and expansion of the flag leaf, when the final leaf number (FLN) is defined. In maize crop the vegetative development overlaps the reproductive one. Maize is a *monoecious* crop, it differs in the pattern of initiation and development of pistillate as well as staminate flowers. The initiation of floral *primordia* corresponds to the time when a particular leaf from the top begins to elongate. The duration of floral primordial varies with the variety and weather. When the number of leaves to be developed on the stem is constant, the leaf number can be taken as a measure of physiological age of plant. This applies to photoperiod insensitive varieties and also to the same variety grown under the same environmental conditions.

Leaf number (LN) is related to some reproductive developmental stages, such as ears and tassel initiation (Forsthofer *et al*., 2004). As leaf number increases, crop leaf area index (LAI) for net photosynthesis and crop biomass production (dry matter) also increases. Application of nutrients in maize is also related to leaf number (LN), being recommended at V4 (four expanded leaves), V7 (seven expanded leaves), and V11 (eleven expanded leaves) (Forsthofer *et al*., 2004). Thus any management practice or biotic or abiotic stresses that effect the leaf development may potentially impact the reproductive growth and development and ultimately influence the crop yield.

Matshushima (1980) introduced the idea of leaf number index (LNI) *i.e; Foliar Index* in rice crop to determine the panicle development stages in relation to leaf growth. The LNI explain much variation in leaf number. LNI is the number of leaves before heading divided by the number of days from sowing to heading and multiplied by 100. Leaf number index can be used as a tool to identify the tassel or cob differentiation age of that particular hybrid or variety of maize (Cao-bin *et al*., 2005).

Material and Methods

The experiment was conducted in field number 8, Orchard block of the farm of Agricultural College, Bapatla. The farm is geographically located on the eastern side of the peninsular India, situated at an altitude of 5.49m above mean sea level,15°54' Northern latitude,80°25' Eastern longitude and about 7 km away from Bay of Bengal in Agro-climatic Zone III of Andhra Pradesh.

Number of leaves plant^{-1}

Leaf appearance rate was calculated on leaf tip (LN Tip) and on expanded leaf (LN expn) basis. A leaf was assumed expanded when ligule is visible.

The accumulated leaf number (LN) was calculated starting at crop emergence by calculating LAR was calculated as per Strek *et al*., 2009 presented in the following.

$$LN = \sum LAR$$

Five plants were randomly selected and tagged in each plot after leaving boarder rows on all sides .The photosynthetic rate was recorded in the top most fully expanded leaf in the stem of the tagged plant at every seven days interval in all the treatments.

Leaf number index (LNI)

Leaf number Index is related to the developmental stage of growing reproductive part of the plant, this relationship holds the tassel or cob differentiation inside the plant. The physical appearance of the nth number of that particular stage can be explained by the expression of its index value by using the following formula (Mastishima, 1980).

$$LNI = \frac{Number\ of\ leaves\ developed\ at\ particular\ time}{Number\ of\ leaves\ to\ be\ developed} \times 100$$

Different hybrids / varieties vary in the number of leaves on the main stem. Hence, the leaf number index was corrected by using the correction factor (CF).

$$Correction\ factor\ (C.F.) =$$

$$=(100 - LNI) \times \frac{maximum\ number\ of\ leaves\ attained - Total\ number\ of leaves}{10}$$

The corrected leaf number index then becomes:

$$\textbf{\textit{Corrected leaf number index}} = \textbf{\textit{Leaf number index}} + \textbf{\textit{C.F}}$$

Statistical Design:

The data were analyzed by following the analysis of variance (ANOVA) technique as suggested by Panse and Sukhatme (1978). The statistical hypothesis of equalities of treatment means was tested by the test in ANOVA at 5 percent level of significance to compare different treatment means.

Results and Discussion

Maize is an economically important crop because of its widespread commercial production and utilization. It is well known that nutrient deficiency in most cultivated crops during the growth season causes imbalance, leading to low productivity and reduction in yield. Nutrient supply in critical stage of the crop, especially during the phase shift from vegetative phase to reproductive stage determines the crop productivity. Leaf number index of six maize hybrids varied significantly, increased with age of the crop (Table 1.1, 1.2 and figure 2.1, 2.2). In *rabi* 2016-17, at 7 DAS, LNI was significantly high in Pinnacle, low in DKC 9120 and 900 M Gold compared to DKC 9081 and DKC 9042. At 14 DAS, the hybrids V2 to V6 were on par, had LNI greater than 900M Gold. At 21 DAS, it was high in DKC 9142 and low in DKC 9081and 900M Gold compared to DKC 9120, DKC 9042 which showed parity with Pinnacle. At 35 DAS, LNI was low in DKC 9081 followed by DKC 9120 and high in DKC 9142 followed by 900M Gold. It was intermediate in other two and on par. At 42 DAS, DKC 9042 had high LNI followed by Pinnacle and 900M Gold had low LNI followed by DKC 9120 and the other two had the value in between and were on par. At 49 DAS, DKC 9081 had high LNI followed by DKC 9042 and 900M Gold had low LNI, the other three were in between. At 56 DAS, DKC 9042 had high LNI value followed by Pinnacle which showed parity with DKC 9081 and 900M Gold, DKC 9120 had low value of LNI followed by DKC 9142. Later at 63 DAS, all hybrids had low LNI compared to DKC 9042 and further all were equal. The magnitude of increase in LNI was more from 21 to 28 DAS.

In *rabi* 2017-18 also, LNI of maize hybrids varied significantly. At 7 DAS, it was high in DKC 9142, Pinnacle followed by DKC 9120 and low in DKC 9042 followed by 900M Gold. At 14 DAS, along with DKC 9142 and Pinnacle, DKC 9042 also had high LNI, followed by DKC 9120 compared to DKC 9081 and 900M Gold. At 21 DAS, DKC 9142 and Pinnacle maintained the domination followed by DKC 9120, 900M Gold and less in other two. At 28 DAS, compared to 900M Gold and DKC 9042, other hybrids had LNI on par. At 35 DAS, Pinnacle had high LNI followed by DKC 9142. The low LNI was noticed in DKC 9081 followed by DKC 9042 and other two had the value in between. At 42 DAS, compared to V1, V4 and V5, DKC 9142 had high LNI followed by Pinnacle and DKC 9120. At 49 DAS, Pinnacle had high and DKC 9120 had low compared to other hybrids. Finally at 56 DAS, Pinnacle and 900M Gold followed by DKC 9142 showed domination over other three. The magnitude of increase in LNI was more at 7 to 14 DAS for DKC 9142, DKC 9042, Pinnacle at 21 to 28 DAS for DKC 9081 and at 28 to 35 DAS for 900M Gold and DKC 9120.

The appearance of leaf is depended on genetical potential and respond to the photoperiod and temperature (Nesmith and Ritchie, 1992). The final leaf number (FLN) depends on the rate and duration of leaf initiation. The rate is usually calculated from the quotient of the number of leaves produced from sowing until tassel initiation and time elapsed between those events taking into account the number of leaves already present in the embryo (Padilla and Otegui, 2005). According to Tollenaar *et al* (1979) the phase shift from vegetative stage to reproductive phase was initiated at 35 DAS, where the reproductive

tissue (tassel and cob) differentiation occurs.

In the present investigation, for the hybrids studied, the phase shift from vegetative to reproductive was initiated at 28 DAS to 34 DAS. The number of days to tassel primordial initiation varied from 28.5 to 30.0 DAS in both the seasons. Whereas the number of days to initiation of cob development varied from 32.25 to 33.0 in *rabi* 2016-17 and 31.13 to 34.0 in *rabi* 2017-18. The LNI at the time of primordial initiation for tassel and cob development lies between 55.4 to 73.9. Cao - Bin *et al* (2005) reported that the corresponding LNI for the tassel and cob development ranged from 55 to 98. During both the seasons, the visible leaf number that coincides with initiation of tassel development varied from 9th to 11th depending on hybrid and that of cob varied from 10th to 11th leaf. This indicates that the phase shift from vegetative to reproductive coincides with the visible leaf number 9th to 11th.

Cao - Bin *et al* (2005) observed the development of reproductive organs anatomically and reported that the development of reproductive organs progressed during 42 to 49 DAS. Streck *et al* (2009) observed the complete heading of tassel and silking of the cob, an important stage for anthesis during 56 to 63 DAS. He reported that it coincides with visible leaf number 14th to 15th with LNI of 90 to 99. Tollenaar *et al* (1979) stated that maximum LNI value 100 represents the completion of the reproductive cycle of the plant and it is attained at 77 DAS corresponding to attainment of final leaf number, the translocation of assimilates is continued for maturation of grain. The results of present investigation are in confirmation with these reports. But the final leaf number and maximum LNI were attained at 70 DAS.

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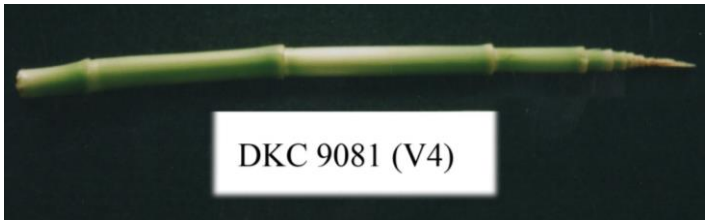


Plate 1 Tassel Initiation of DKC 9081

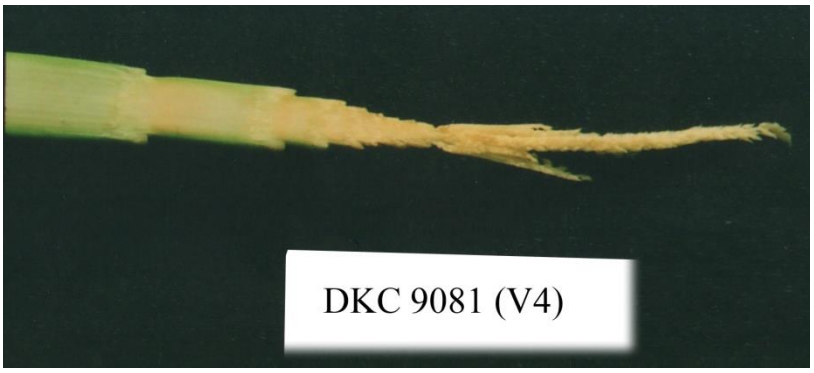


Plate 2 Cob Initiation of DKC 9081

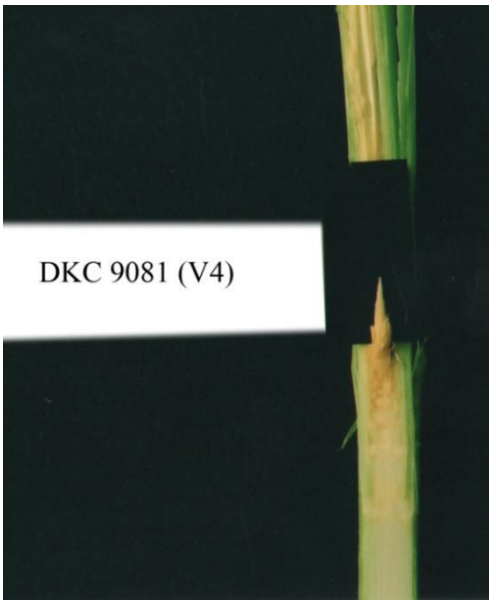


Plate 3 Close view of Cob Initiation after dissection of DKC 9081

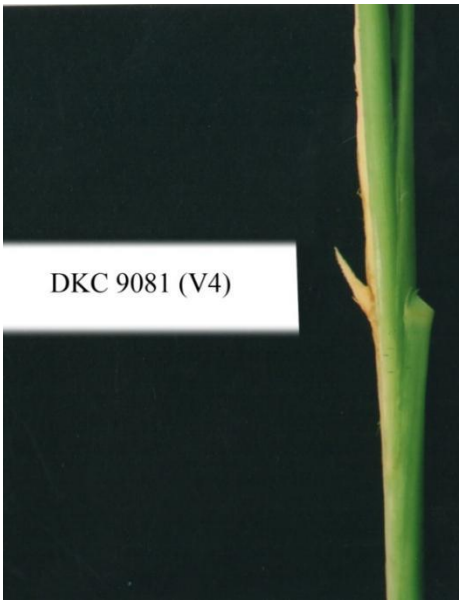
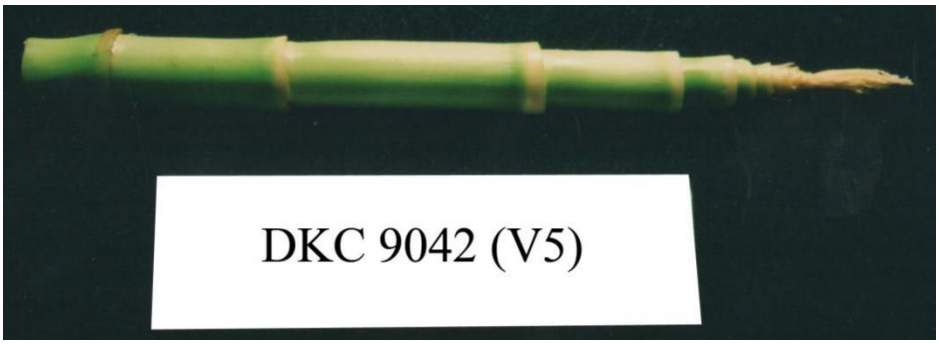


Plate 4 Close view of Cob Initiation of DKC 9081

A.



B.

Plate 5 A & B Tassel Initiation in DKC 9042

A.

B.

Plate 6 A & B Cob Initiation in DKC 9042

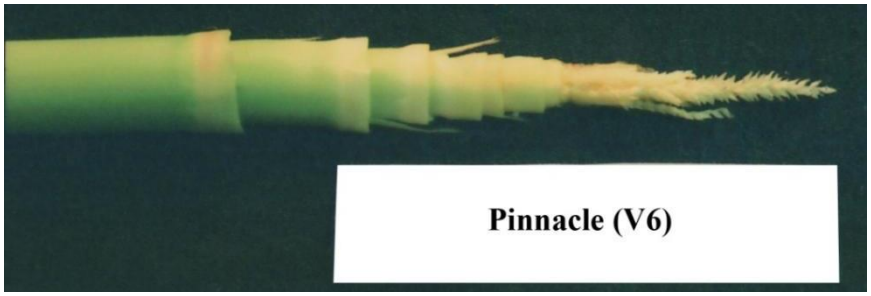


Plate 7 Tassel Initiation of Pinnacle

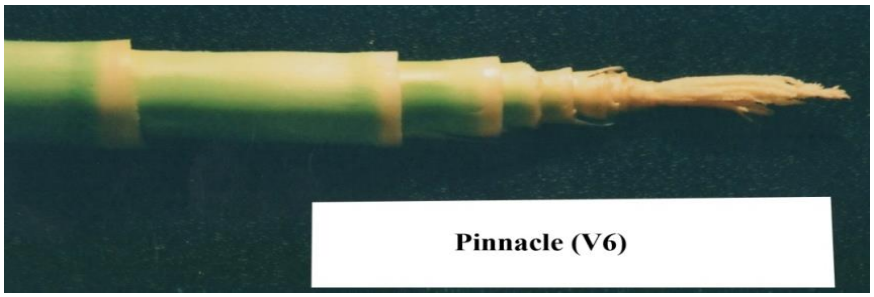


Plate 8 Close View of Tassel Initiation of Pinnacle

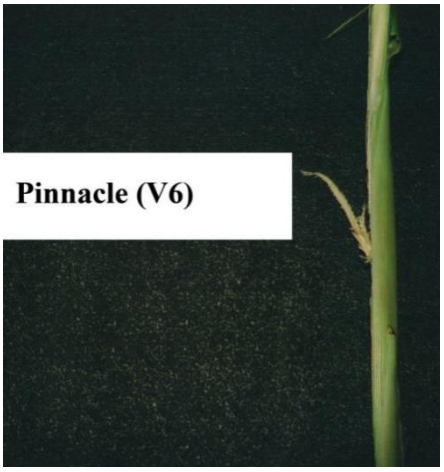


Plate 9 Cob Initiation of Pinnacle

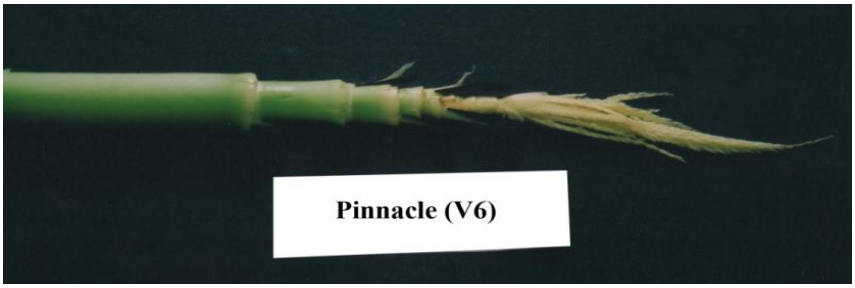


Table 1.1 Leaf number index (LNI) of maize hybrids during *rabi* 2016-17

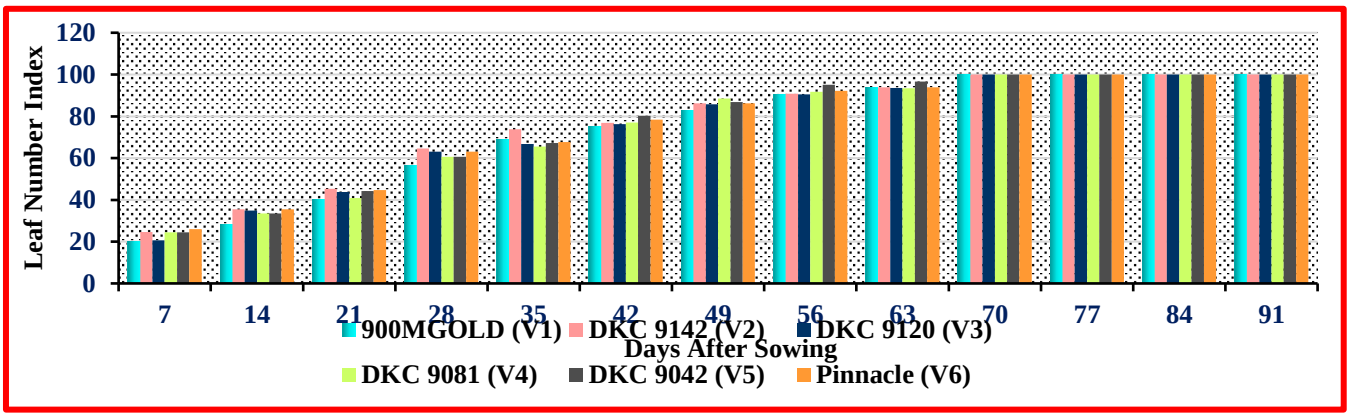
Days After Sowing	7 DAS	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS	70 DAS	77 DAS	84 DAS	91 DAS	Harvest
900MGold (V1)	20.3	28.2	40.0	56.3	68.8	75.0	82.8	90.6	93.8	100.0	100.0	100.0	100.0	
DKC 9142 (V2)	24.7	35.4	45.3	64.6	73.9	76.9	86.2	90.8	93.9	100.0	100.0	100.0	100.0	
DKC 9120 (V3)	20.6	34.8	43.8	63.1	66.8	76.2	85.7	90.5	93.6	100.0	100.0	100.0	100.0	

DKC 9081 (V4)	24.5	33.4	40.9	60.1	65.5	77.0	88.5	91.8	93.4	100.0	100.0	100.0	100.0	
DKC 9042 (V5)	24.5	33.4	44.2	60.1	67.2	80.3	86.9	95.1	96.7	100.0	100.0	100.0	100.0	
Pinnacle (V6)	26.0	35.4	44.7	63.1	67.7	78.5	86.2	92.2	93.9	100.0	100.0	100.0	100.0	
SEm±	0.09	1.32	0.53	4.27	0.18	0.27	0.33	0.58	0.51					
CV%	0.59	10.37	6.81	10.62	0.37	0.51	0.56	0.89	0.77					
CD (p=0.05)	0.21	2.69	1.13	NS	0.39	0.53	0.72	1.23	1.09					

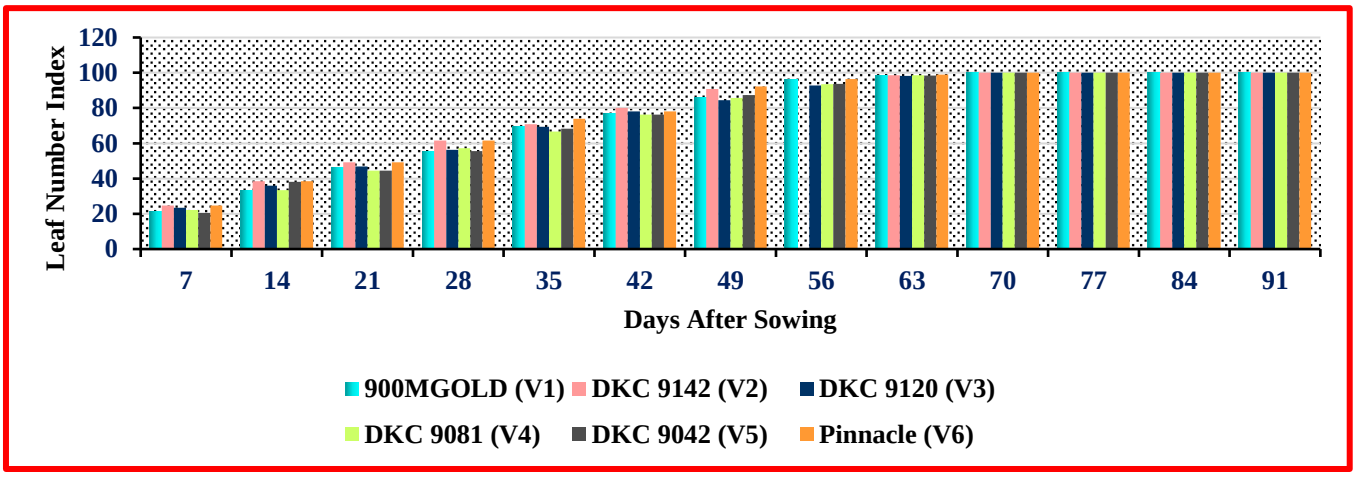
Table 1.2 Leaf number index (LNI) of maize hybrids during *rabi* 2017-18

Hybrids	**7 DAS**	**14 DAS**	**21 DAS**	**28 DAS**	**35 DAS**	**42 DAS**	**49 DAS**	**56 DAS**	**63 DAS**	**70 DAS**	**77 DAS**	**84 DAS**	**91 DAS**	**Harvest**
900MGold (V1)	21.6	33.0	46.2	55.4	69.3	76.9	85.9	96.1	98.5	100.0	100.0	100.0	100.0	
DKC 9142 (V2)	24.7	38.5	49.3	61.6	70.8	80.0	90.8	94.5	98.6	100.0	100.0	100.0	100.0	
DKC 9120 (V3)	23.4	35.9	46.9	56.3	69.3	78.1	84.4	92.8	98.14	100.0	100.0	100.0	100.0	
DKC 9081 (V4)	22.2	33.4	44.4	57.1	66.6	76.2	85.7	93.5	98.6	100.0	100.0	100.0	100.0	
DKC 9042 (V5)	20.6	38.1	44.4	55.5	68.2	76.2	87.3	93.6	98.4	100.0	100.0	100.0	100.0	
Pinnacle (V6)	24.6	38.5	49.3	61.6	73.9	78.1	92.3	96.5	98.9	100.0	100.0	100.0	100.0	
SEm±	0.10	0.53	0.53	3.25	0.20	0.25	0.48	0.68	0.25					
CV%	0.4	1.4	5.8	10.6	0.4	0.7	0.6	0.9	0.65					

	5	3	1	8	5	8	8	6						
CD (p=0.05)	0.29	2.10	1.03	5.59	0.85	0.68	0.89	1.03	NS					



Leaf number index (LNI) of maize hybrids during *rabi* first season



Leaf number index (LNI) of maize hybrids during *rabi* second season