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Full Length Research Paper

Effect of leaf cutting on physiological traits and yield of two rice cultivars

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Field experiments were conducted during two summer seasons 2003 and 2004 to study the effect of leaf cutting on physiological traits and yield of two rice cultivars hybrid (H5) (IR 70368 A /G 178) and inbred rice. The leaf cutting was followed from flag leaf as follows: 1.) L; Control = without leaf cutting, 2.) L1; flag leaf cut, 3.) L2; second leaf cut, 4.) L3; third leaf cut, 5.) L4; both flag leaf and second leaf cut. 6.) L5; flag leaf, second leaf and third leaf cut together. A split plot design with four replications was used; the main plots were devoted to the cutting of leaves, while the sub-plots were assigned to the two rice cultivars. Chlorophyll, sugar, starch and grain yield parameters were severely affected by L5, followed by L4, L1, L3 and L2 in sequence. However, as a single component affecting maximum to these parameters is the removal of flag leaf. The flag leaf contributed maximum to the yield of rice grains. L5, L4, L1, L2 and L3 treatments grain yield (relative % of control) by 59.87, 94.92, 44.89, 29.58 and 19.98 % respectively. Flag leaf contributed to 45% of grain yield and is the single most component for yield loss. The contribution of leaf removal in hybrid rice was minimum, suggesting the probability of maximum translocation of photosynthesis from stem to the grain during grain feeling stage of hybrid rice after leaf removal.

Key words: Rice, leaf cutting, physiological traits, yield and cultivars.

INTRODUCTION

In rice, 60 - 90% of total carbon in the panicles at harvest is derived from photosynthesis after heading, while 80% or more of nitrogen (N) in the panicles at harvest is absorbed before heading and remobilized from vegetative organs (Mae, 1997). Liu et al. (1986) found that both economic and biological yields were closely correlated with optimum leaf area index (LAI) of plant community of different rice cultivars. Jiang et al. (1988) have also reported that high grain yield in rice was due to high total dry matter (TDM, g /plant). Agata and Kawamitsu (1990) have found high grain yield in hybrids was realised by high TDM which was based on high leaf area rather than leaf photosynthetic rate. Niranjanamurthy et al. (1990) found that leaf area at 45 days from sowing was positively associated with TDM and grain yield, while the leaf area at flowering showed either with TDM or grain yield.

Leaf senescence during reproductive and ripening stages is directly related to biomass production and grain yield of rice crop (Ray et al., 1983; Misra and Misra, 1991b; Misra et al., 1997). Also, during leaf senescence, chlorophyll content also decline but the rate of the decline is much slower than Rubisco content (Makino et al., 1983; Msra and Misra, 1986; Ladha et al., 1998; Dilnawaz et al., 2001). Single leaf net photosynthetic rate (P_n) is closely correlated with Rubisco content (Makino et al., 1983) and nitrogen content (Yoshida and Coronel, 1976; Peng et al., 1995). The decline in P_n is also correlated with loss of chlorophyll during leaf senescence (Camp et al., 1982; Kura-Hotta et al., 1987). Therefore, the contents of Rubisco, Nitrogen and chlorophyll have been used to quantify leaf senescence (Ray et al., 1983; Makino et al., 1983, 1984a; Misra and Misra, 1986; Kura-Hotta et al., 1987). The top three leaves contribute most to grain yield (Yoshida, 1981; Ray et al., 1983; Misra, 1986, 1987; Misra and Misra, 1991a). Greater carbohydrate translocation from vegetative plant parts to the spikelets (Misra, 1986; 1987; Song et al., 1990), and larger leaf area index (LAI) during the grain-filling period, but the physiological basis for heterosis remains

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Table 1. Leaf area (LA, cm^2)/ plant, chlorophyll content (SPAD units), total dry matter (TDM) production (g)/main stem, Spikelets per unit leaf area (dm)–ratio, panicle length, spikelet number, number of grains per panicle, test weight (1000 grain weight) and grain yield (ton/ ha) of hybrid rice variety H5 and inbred Egyptian local cultivar Sakha 103 as affected by leaf cutting.

Characters / Treatment	LA (cm^2)	Chl (Spad units)	TDM (g)/ plant	Panicle length (cm)	Spikelet Number	No of grains / panicle	1000 grain weight (g)	Grain yield (ton / ha)
Control(L)	206 A	44 A	4.79 A	22.95 A	0.66 A	135 A	25.9 A	11.9A
L1	163 D	41 BC	2.66 D	12.63 D	0.50 B	75 D	25.2BC	8.39 C
L2	172 C	42 AB	3.39 B	16.07C	0.60 A	95 C	25.5AB	9.57 B
L3	191 B	43 AB	3.87 B	18.36 B	0.67 A	109 B	25.8 A	5.99 E
L4	157 E	39 CD	3.02 C	11.48 E	0.40 C	69 E	25.0CD	4.80 F
L5	152 E	37 D	1.94 E	09.18 F	0.29 D	55 F	24.7 D	6.58 D
L.S.D, P 0.0 5	**5.87**	**2.6**	**0.32**	**0.81**	**0.078**	**5.12**	**0.41**	**0.46**
Cultivar								
H5	176 A	42 A	3.74 A	17.78 A	0.56 A	99 A	25.45 A	9.27 A
Sakha 103	171 A	40 A	2.82 B	12.44 B	0.47 B	80 B	25.30 A	6.49 B
Interaction	**NS**	**NS**	*****	******	**NS**	******	**N S**	******

1- Control = (no leaves cutting of plant) 2- L1 = first leaf Cutting (flag leaf Cutting) 3- L2 = Cutting of second leaf 4- L3 = Cutting of third leaf 5- L4 = Cutting of first and second leaves 6- L5 = Cutting of first, second and third leaves.

unknown (Peng et al, 1998). Delaying sowing date sharply decreased the leaf area index, dry matter production and chlorophyll content (El-Khoby, 2004; Misra, 1986; 1987). In addition, delaying sowing date by 2 - 4 weeks significantly reduced the period from sowing to heading. The top three leaves not only assimilate majority of carbon for grain filling during ripening phase, but provide large proportion of remobilized- nitrogen for grain development during their senescence (Misra and Misra, 1991a; Mae, 1997). Changes in Rubisco, nitrogen, and chlorophyll contents of -4th (counting from the top) and flag leaves during leaf senescence have been stu-died (Mae et al., 1983; Makino et al., 1984; Ladha et al., 1998). In a study with ^{14}C-sucrose feeding to senescing flag leaves and the distribution of ^{14}C- radio labels in sugar and starch amounted to 24% in the flag leaf, and 18% in grains, while that in the free and protein amino acids (nitrogenous compounds) amounted to 6.5% in the flag leaf and 6.2% in grains, indicating that a large proportion of ^{14}C was distributed in the sugar and starch fractions (Mitsuru, 1992).

In the present study, the effect of leaf cutting on the chlorophyll and carbohydrate content, and yield components of hybrid and inbred rice is elucidated.

MATERIALS AND METHODS

During two successive summer seasons, 2003 and 2004, two field experiments were conducted at the Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh Egypt, to study the effect of leaf cutting on some physiological traits and yield of two rice cultivars - hybrid rice H5 and inbred rice Sakha 103.

Experiments were arranged in split plot design with four replications. The main plots were devoted to cutting of leaves as follows:

i.) L; Control = without leaf cutting.
ii.) L1; flag leaf cut.
iii.) L2; second leaf cut.
iv.) L3; third leaf cut.
v.) L4; both flag leaf and second leaf cut.
vi.) L5; flag leaf, second leaf and third leaf cut together.

The sub-plots were assigned to the two rice varieties. Nitrogen fertilizer, as urea (46% N) was applied at the rate of 144 kg N/ha on two doses, (i) two third incorporated in dry soil before the planting and (ii) the other third at panicle initiation stage (PI). Planting of rice was done after barley was harvested it on May 15th in both 2003 and 2004. Thirty day old seedlings were transplanted [one seedling /hill or (single plant) per hill adopting a spacing 20 x 20 cm apart between rows and hills]. The sub plots area was 6 m^2 each.

Leaf area (cm) of main tiller/hill, spikelets/ leaf area, chlorophyll content and dry matter production (g) was measured at the anthesis (heading stage). Chlorophyll content was evaluated with a Chlorophyll meter, 5 SPAD-502, Minolta Camera Co. Ltd., Japan. (Futuhara et al., 1979) and expressed in Spad units. The leaf area of plant was measured by leave area meter (Make Japan and Model CI-700LP). While at thirty days after heading (at maturity stage) . Ten panicles from every plot were taken to study panicle length (cm), number of grains /panicle, 1000-grain weight (g). Grain yield was measured for 4 m^2 area at harvest. Also sugar and starch percentage in stem, panicle, plant, total sugar and starch % in plant resulted to each leaf were evaluated. Starch and sugar % were determined in the powdered materials following the methods developed by Yoshida et al. (1972). All data collected were subjected to the standard statistical analysis and computed for two years according to Gomez and Gomez (1984) and IRRI computer program was used.

RESULTS AND DISCUSSION

Table 1 shows that all the growth and yield parameters studied e.g. leaf area (cm^2)/ plant, chlorophyll content (SPAD units), total dry matter (TDM) production (g)/main

Table 2. Effect of leaf cutting on sugar and starch percentage in stem, panicle and total (stem + panicle) of rice cultivars cv. H5 and cv. Sakha 103. Leaf cutting treatments L, L1 to L5 are same as Table 1.

Characters / Treatments	Sugar % in stem	starch % in stem	Sugar % in panicle	Starch % in panicle	Sugar % in plant	starch % in plant
Control(L)	4.58 A	4.25 A	5.42 A	57.15 A	10 A	54.64 A
L1	2.86 D	2.53 D	3.34 D	39.48 D	6.19 C	41.89 C
L2	3.48 C	3.09 C	3.94 C	45.11 C	6.4 C	48.23 B
L3	3.80 B	3.48 B	4.43 B	49.72 B	8.18 B	53.20 A
L4	2.71 D	2.30 E	2.89 E	37.27 D	5.60 D	40.95 C
L5	2.35 E	2.00 F	2.40 F	31.31 E	4.04 E	33.25 D
L.S.D at 5 %	**0.32**	**0.15**	**0.29**	**3.45**	**0.57**	**3.77**
Cultivar(V)						
H5	3.56 B	3.18 A	4.04 A	45.59 A	7.10 A	46.48 A
Sakha 103	3.03 A	2.7 B	3.43 B	54.64B 3.43 B 41.09 B3.43 B	6.40 B	44.24 B
Interactions L X V	**N S**		**N S**	**N S**	**N S**	

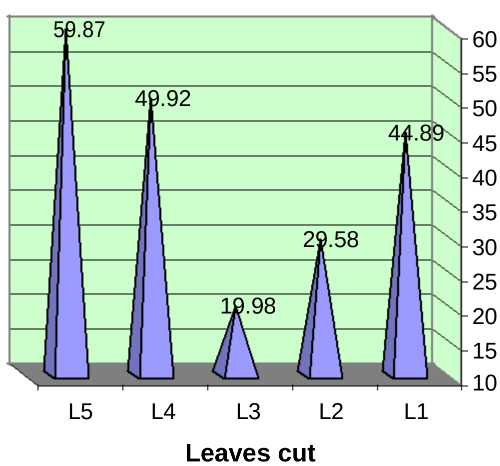

Figure 1A. A loss of grain yield as affected by leaf cutting.

stem, Spikelets per unit leaf area –ratio, panicle length, spikelet number, number of grains per panicle, test weight (1000 grain weight) and grain yield (ton/ ha) of hybrid rice cultivar H5 and inbred Egyptian local cultivar Sakha 103 was affected significantly by leaf cuttings. All the para-meters showed maximum value under control condition without any leaf cutting. The values decreased in order L3, L2 and the value decreased significantly in L1 and was the least in L5. The hybrid rice cultivar H5 had rela-tively higher but non-significant leaf area (cm^2) per plant, chlorophyll content and test weight (1000 grain weight) than the traditional inbred Egyptian rice cultivar Sakha 103 (Table 1). On the other hand, the hybrid showed significantly higher total dry matter (TDM) production (g)/main stem, Spikelets per unit leaf area (CM), panicle length, spikelet number, number of grains per panicle, and grain yield (ton/ ha) (Table 1) . This shows hybrid vigour of H5 rice over the traditional inbred Egyptian rice cultivar. These results corroborate with the report on the effect of leaf cutting on chlorophyll content, leaf area, spikelet number and yield parameters in pearl millet (Misra, 1986, 1987, 1995; Misra and Misra, 1991b).

High grain yield in rice was reported due to high TDM - total dry matter per plant (Yoshida, 1981; Ray et al., 1983; Jiang et al., 1988). Agata and Kawamitsu (1990) have found high grain yield in hybrids was realized by high TDM which was based on high leaf area rather than leaf photosynthesis. Misra (1986, 1987, 1995) and Misra and Misra (1987) reported that the harvest index (HI) is the ultimate determinant for grain yield in cereals, and the cultivar differences or other factors affecting crop yield regulates grain yield through the TDM.

Table (2) shows the sugar and starch percentage was maximum in the control, followed by L3. While L5 and L1 (cutting of flag leaf) reduced both sugar and starch con-tent to the maximum followed by L4 and L2. In both L5 and L1 the flag leaf is cut. Flag leaf contributed to 45% of grain yield (Misra, 1995; Mitsuru, 1992) and is the single most component for yield loss.

Figure (1 a, b) shows that in L5, L4, L1,L2 and L3 treat-ments the loss of grain yield was 59.87, -94.92, -44.89, -29.58 and 19.98% of control, respectively. Flag leaf contributed to 45% of grain yield and is the single most component for yield loss. These results are in agreement with earlier reports on the contribution of flag leaf and top three leaves to grain yield (Yoshida, 1981; Ray et al., 1983; Misra, 1986; 1987, Misra and Misra, 1991). Hybrid cereal crops show greater carbohydrate translocation from vegetative plant parts to the spikelets (Misra, 1986, 1987, 1995; Song et al., 1990). Probably these parameter

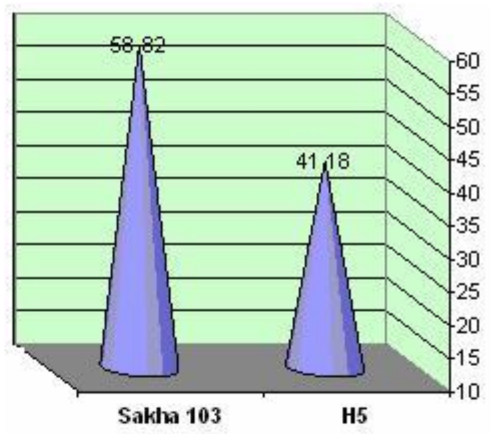

Figure 1B. Cultivar difference in grain yield loss as affected by leaf cutting.

play a major role in the improved grain yield of hybrid rice cv. H5 (Figure 1B) in the present study. Better sugar and starch accumulation, and translocation in hybrid rice could be one of the important factors contributing to higher TDM and higher yield in adverse conditions. The photosynthetic translocation as a fraction of TDM in hybrid plants along with higher sugar translocation and starch accumulation in the rice plants could contribute to a higher grain yield and contributing tohybrid vigour in rice.

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