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Full Length Research Paper

Interference of five problematic weed species with rice growth and yield

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Five weed species namely, *Cyperus rotundus* L., *Cyperus difformis* L., *Echinochloa colonum* (L.) Link., *Paspalum paspaloides* (Mich.) Scribner, and *Marsilea minuta* L. were selected for the assessment of their level of competition with two commonly grown rice varieties viz. Basmati-385 and Super Basmati. Root and shoot growth as well as grain yield, in both rice cultivars, were adversely affected due to the weed competition in the field experiments. In general, Super Basmati was found to be comparatively more tolerant to weed infestation than Basmati-385. There were 6 to 40% and 21 to 56% reduction in grain yield of Super Basmati and Basmati-385, respectively, due to different weed species. *E. colonum* was found to be the most damaging weed which resulted in the highest grain yield losses of 56 and 42% in Basmati-385 and Super Basmati, respectively. *P. paspaloides* was found to be the second most damaging weed species which caused 47% yield losses in Basmati-385. It was concluded from the study that *E. colonum* was the most competitive weed. It resulted in the highest yield losses in rice especially in var. Basmati-385.

Keywords: Rice, weeds, yield losses.

INTRODUCTION

Rice (*Oryza sativa* L.) is a crop of global importance, only second to wheat. It serves as the basis for life for half of the world's population, particularly in East and South East Asia. It is a great source of nutritional calories; 95% is consumed by humans as an unprocessed food. Indica rice type accounts for 80% of the cultivated rice, and is a staple food for more than two billion people in China, India and Bangladesh along with more millions in other countries who depend on it for more than half the proteins and calories they consume. About 90% of the world's rice is grown in Asia (IRRI, 1993).

In Pakistan, rice is grown under varied climatic, soil and hydrological conditions. It is the third largest exporter of rice in the world with an export volume of up to US $ 394 million (Chandio, 2009). Pakistani rice is globally known for its particular aroma and taste. The average grain yield of rice in Pakistan is 2107 kg ha^{-1}, which is far below the world's average (Anonymous, 2007). Among other factors, weeds play a major role in low yield of rice in Pakistan. In Pakistan, the weeds cause more than $ 18.2 billion losses in agricultural production annually. Of these, about $ 12 billion losses are attributed to the production losses caused by weeds competition and $ 6.2 billion on chemical weed management and other weed control practices. It is estimated that average crop losses due to weeds in Pakistan is about 11.5% in comparison with world losses of 9.5% (Alam, 2003). Rabbani and Bajwa (2001) reported 18 weed species that infest rice in different areas of the Punjab, Pakistan. Among these, *Cyperus rotundus*, *Cyperus difformis, Echinochloa colonum, Paspalum paspaloides* and *Marsilea minuta* were found to be the most abundant weeds in rice fields.

The aim of this study was to investigate the adverse impact of these most common weeds on growth and yield of two commonly grown varieties of rice in Pakistan.

MATERIALS AND METHODS

The experiment was conducted in Botanical Garden, University of

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the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan. Soil of the experimental field was sandy loam in texture having organic matter of 0.69%, pH 7.8, available phosphorus of 6.3 mg kg^{-1}, 0.035% nitrogen and available potassium of 100 mg kg^{-1}. The micronutrient, B, Mn, Fe, Cu and Zn were 1.06, 22.8, 10.8, 1.9 and 1.3 mg kg^{-1} of soil, respectively.

The experiment was conducted in a split plot design. Certified seeds of the two rice varieties namely Basmati-385 and Super Basmati were procured from Punjab Seed Corporation, Lahore Pakistan. Rice varieties were kept in the main plots and weed species in subplots. Each subplot measured 2.5×1.4 m^2. Plots were heavily irrigated and puddling was carried out. NPK fertilizers at 50:60:40 kg h^{-1} were added in the field in the form of urea, triple super phosphate and potassium sulphate, respectively, at the time of field preparation as per the recommendations of the Agriculture Extension Department, Punjab, Pakistan. Nitrogen at 50 kg h^{-1} was top dressed at the time of the panicle initiation.

Rice nurseries of Basmati-385 and Super Basmati cultivars were raised in the Botanical Garden of Punjab University, Lahore, Pakistan. One-month-old rice nursery was transplanted in field subplots with inter and intra row spacing of 22 cm. Plants of five weed species namely, *C. rotundus, C. difformis, E. colonum, P. paspaloides*, and *M. minuta* were transplanted in 1:1 crop weed ratio in the corresponding plots 15 days after rice transplantation. Plots without weeds served as control. Each treatment was replicated thrice. Plots were irrigated with ground water of good quality to maintain flooding.

Three harvests of rice crop after 90, 120 and 150 days of sowing were designed at late vegetative, flowering and maturity stages, respectively. At each harvest, plants were carefully uprooted, washed under tap water and roots were separated from shoots. Root and shoot length and number of tillers per plant were recorded. All the materials were oven dried at 70°C to constant weight. At the final harvest, grains for yield assessment were separated from shoots and weighed. Percentage losses in root and shoot dry weight and grain yield due to different weeds were also recorded. All the data were analyzed by applying t-test.

RESULTS AND DISCUSSION

Effect of weeds on shoot growth of rice

The number of tillers per plant was markedly reduced in both rice varieties due to weed's competition at all the three growth stages; 90, 120 and 150 days after sowing (DAS). However, the effect was generally more pronounced at the later two growth stages as compared to the early one (90 DAS). Both varieties exhibited non-significant reduction in tillering at 90 days growth stage, due to M. minuta interference. However, at the final growth stage, the difference was significant ($P \leq 0.001$) as compared to the weed free control treatment. Tillering in var. Basmati-385 showed a similar response to interference by *C. rotundus.* Tillering response of Basmati-385 to *C. difformis* competition was non-significant throughout the growth period. Reduction in the number of tillers due to interference of other test weed species viz. *P. paspaloides* and *E. colonum* was significant statistically in Basmati-385 (Figure 1). Super Basmati proved to be less tolerant to weeds competition for this parameter at earlier growth stage than Basmati-385 which showed significant reduction in tillering due to competition of all the five test weeds at all the three growth stages, except *M. minuta* at 90 DAS. The maximum reduction in tillering was recorded in Super Basmati due to *E. colonum* interference followed by Basmati-385 for the same weed (Figure 1).

Shoot length response to weed competition in both test rice varieties was not parallel to that of tillering response. Shoot length in Basmati-385 was significantly reduced at all the three growth stages due to interference of all the five test weed species. Shoot length response of Super Basmati to different weeds was variable at different growth stages. This variety showed a non-significant response to *P. paspaloides* at first growth stage and to *E. colonum* and *C. rotundus* at the final growth stage. Maximum inhibition in shoot length in both test rice varieties was recorded when either *M. minuta* or *C. difformis* was sown in rice fields (Figure 2).

The losses in shoot dry weight due to various weeds varied from 13 to 68% in the two test rice varieties. Maximum reduction (68%) was observed in Basmati-385 due to *M. minuta* followed by 61% due to *E. colonum* in the same variety. Shoot dry weight losses due to interference of other weeds in this variety were above 50% (Figures 3 and 6A). Super Basmati was comparatively more tolerant to the weed competition as compared to Basmati-385. Maximum inhibition of 54% in shoot biomass in this variety was recorded due to *E. colonum* followed by 51% due to *M. minuta. C. rotundus, P. paspaloides* and *C. difformis* were comparatively less damaging and caused only 12, 21 and 30% shoot dry biomass losses in this variety, respectively (Figures 3, 6A). It was evident that cultivars with high plant vigour possess rapid growth, development and adaptive abilities, thus performing better in suppressing weed growth and compete well with weeds (Rao, 2000). Improved crop tolerance and weed suppressive ability (crop competitiveness) are tactics that may reduce the negative impact of weeds on crop yield (Wicks et al., 1986; Linquist and Kropff, 1996). In the case where both crop and weed demand the same resources on a similar time scale, crop tolerance may be the direct result of resource pre-emption (Jordan, 1993).

Effect of weeds on root growth of rice

The effect of C. difformis on root dry weight of Basmati-385 and that of P. paspaloides and C. rotundus on Super Basmati was non-significant statistically. Maximum losses in root dry weight of Basmati-385 were recorded due to *M. minuta* (59%) followed by *P. paspaloides* (50%) and *E. colonum* (47%). This variety exhibited higher tolerance abi-lity to C. difformis where only 18% reduction in root dry weight was recorded as compared to the control (Figures 4 and 6B). In Super Basmati, the highest dry weight losses were observed due to *C. difformis* (57%)

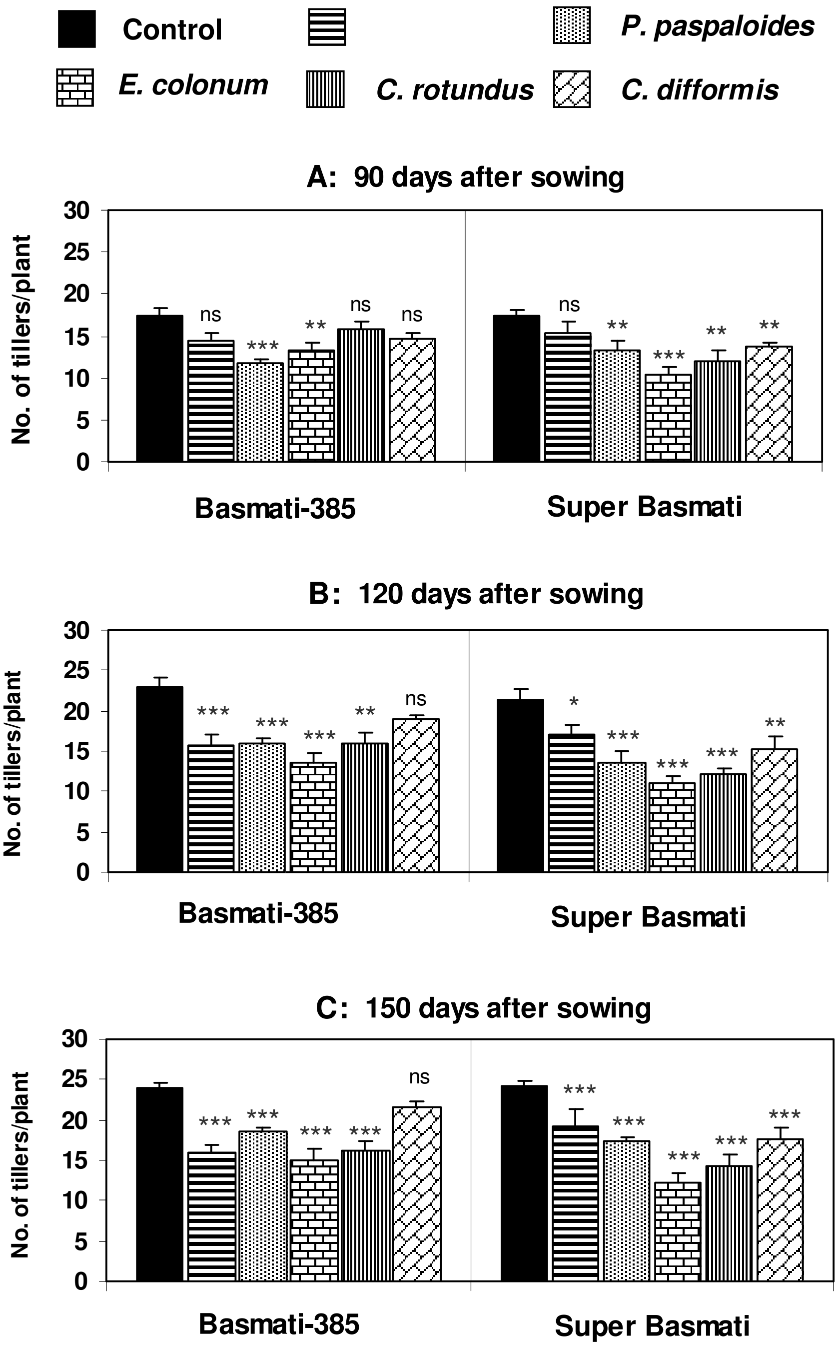

Figure 1. Effect of weeds on number of tillers of rice varieties Basmati-385 and Super Basmati. Bars denote standard errors of the means. *, ** and *** show significant difference from control at P ≤ 0.05, 0.01 and 0.001, respectively, as determined by t-test; ns, non-significant.

followed by *M. minuta* (50%) and *E. colonum* (43%). This variety showed comparatively less susceptibility to *P. paspaloides* and *C. rotundus* than other weeds (Figures 4 and 6B).

Effect of weeds on yield of rice

The results of various parameters of yield such as number of panicle, ear dry weight and grain yield are

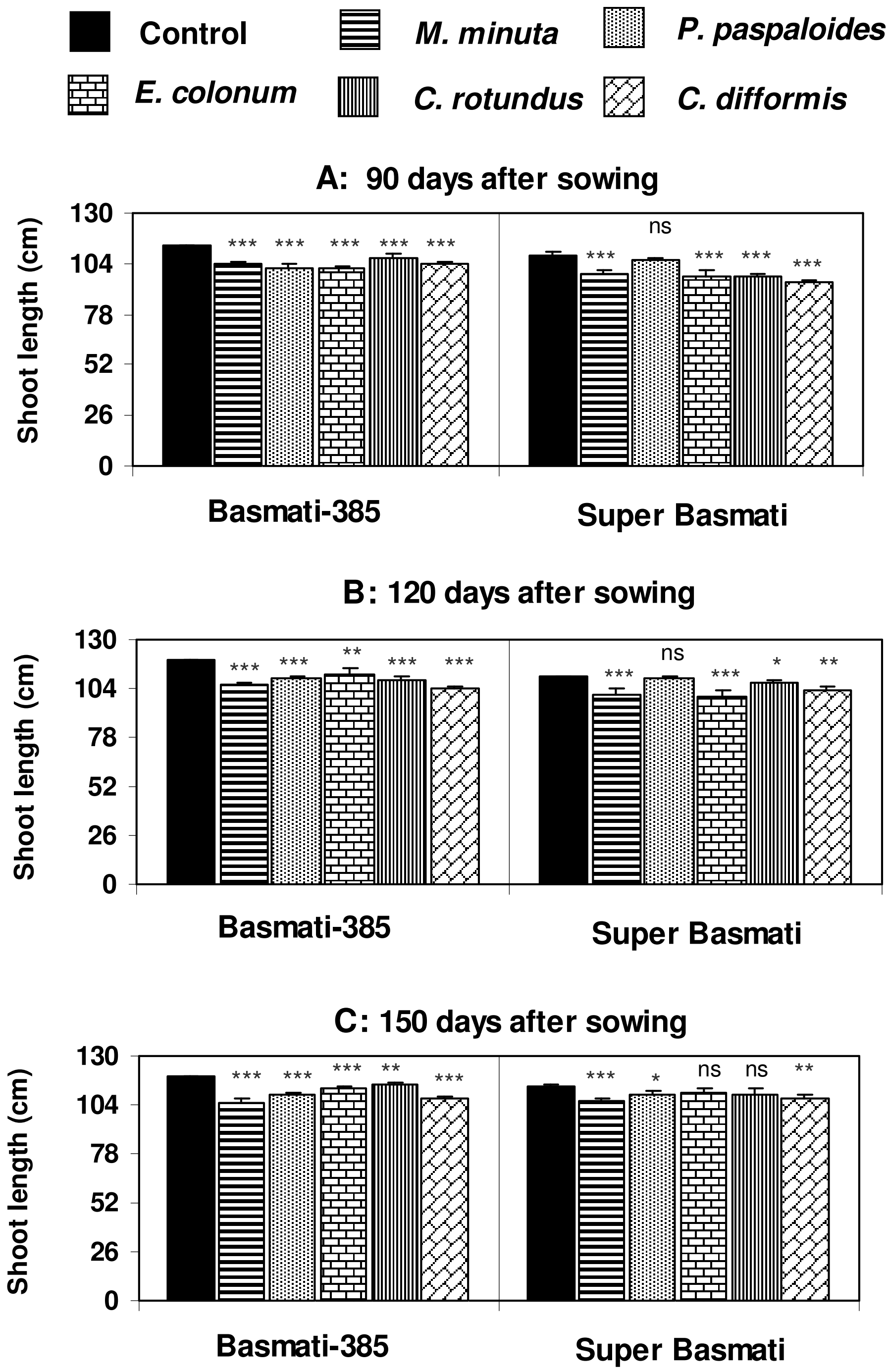

Figure 2. Effect of weeds on shoot length of rice varieties Basmati-385 and Super Basmati. Bars denote standard errors of the means.*, ** and *** show significant difference from control at P ≤ 0.05, 0.01 and 0.001, respectively, as determined by t-test; ns, non-significant.

presented in Figure 5. The effect of the competition of various weeds on the number of panicle varied greatly in the two rice varieties. The number of panicle per plant was reduced significantly in Basmati-385 by all weeds except *C. difformis*. Maximum reduction was recorded due to *P. paspaloides* followed by *E. colonum.* Super Basmati proved comparatively more tolerant to weed competition for this parameter, except for *E. colonum* where a signi-

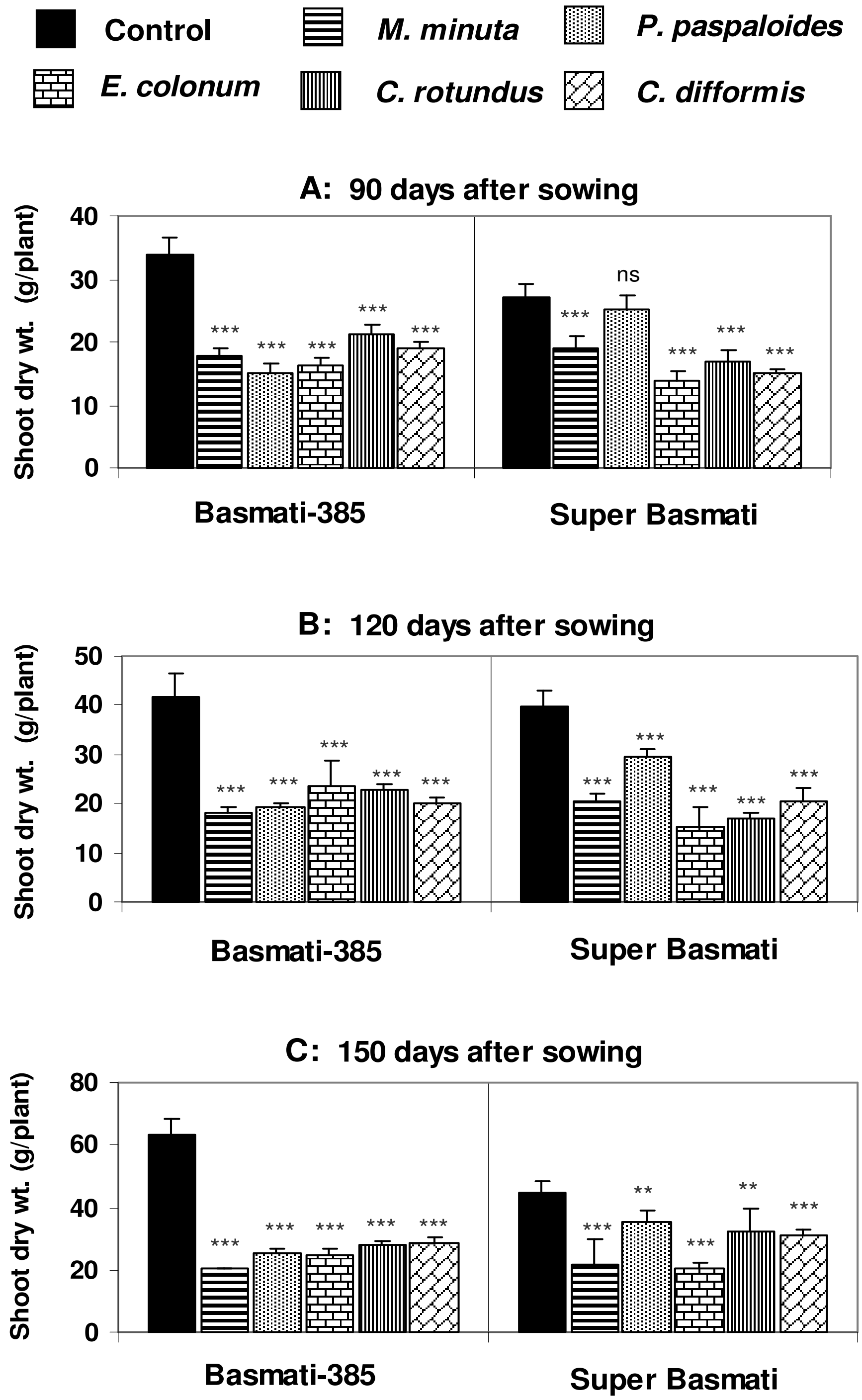

Figure 3. Effect of weeds on shoot dry weight of rice varieties Basmati-385and Super Basmati. Bars denote standard errors of the means. *, ** and *** show significant difference from control at P ≤ 0.05, 0.01 and 0.001, respectively, as determined by t-test; ns: non-significant.

ficant (P ≤ 0.01) reduction in panicle numbers was observed; the effect of other weeds was non-significant (Figure 5A).

Losses in grain yield due to different weeds were more pronounced in Basmati-385 than in Super Basmati. All the weeds suppressed grain yield significantly in this

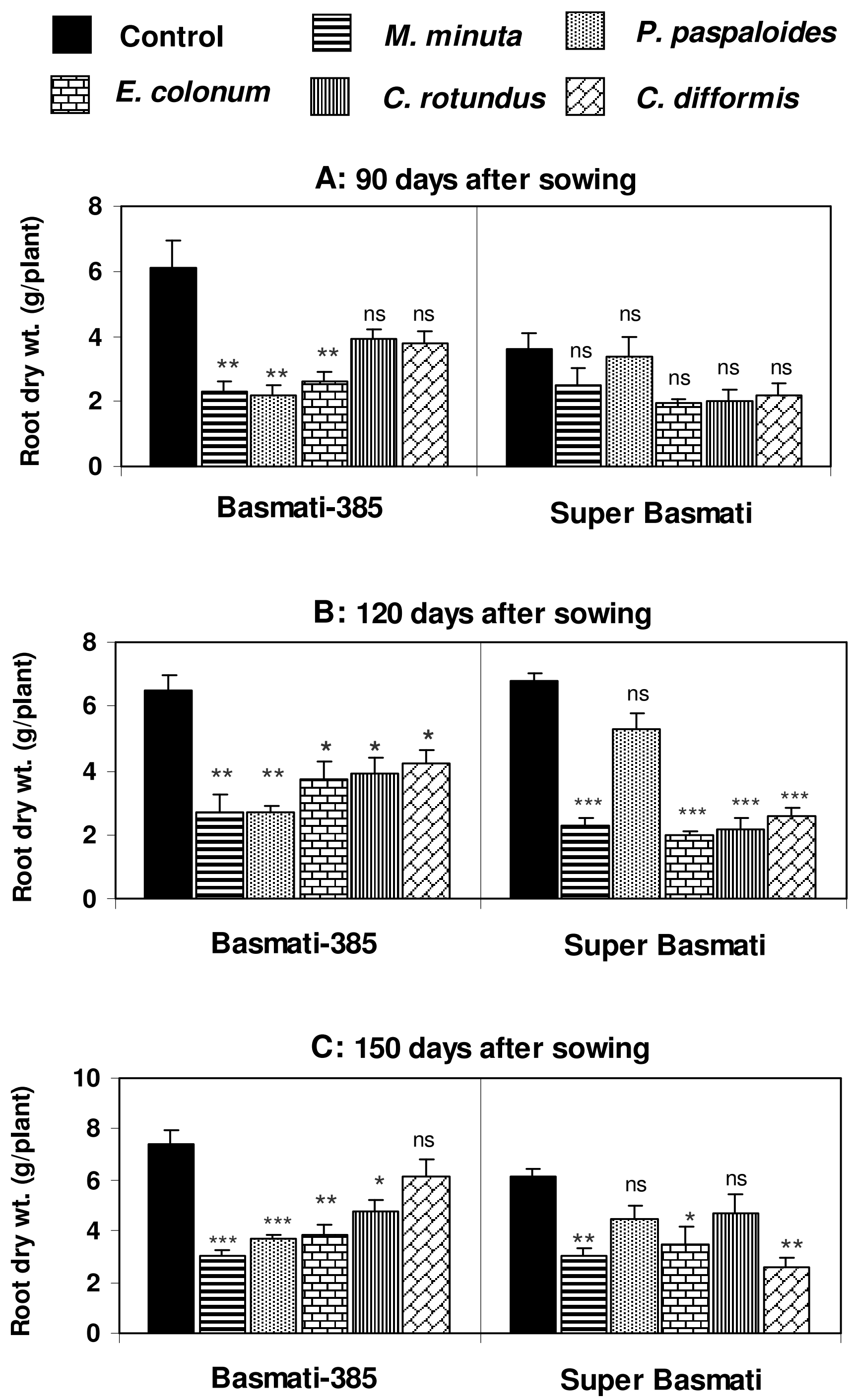

Figure 4. Effect of weeds on root dry weight of rice varieties Basmati-385and Super Basmati. Bars denote standard errors of the means. *, ** and *** show significant difference from control at P ≤ 0.05, 0.01 and 0.001, respectively, as determined by t-test; ns, non-significant.

variety (Figure 5B). However, there was great variability in the damaging effects of different weeds. Maximum losses of 56% were recorded due to *E. colonum* interference followed by 47% due to *P. paspaloides* and *M. minuta* and *C. rotundus* which reduced the yield up to 32% each. Minimum losses of 21% were recorded due to

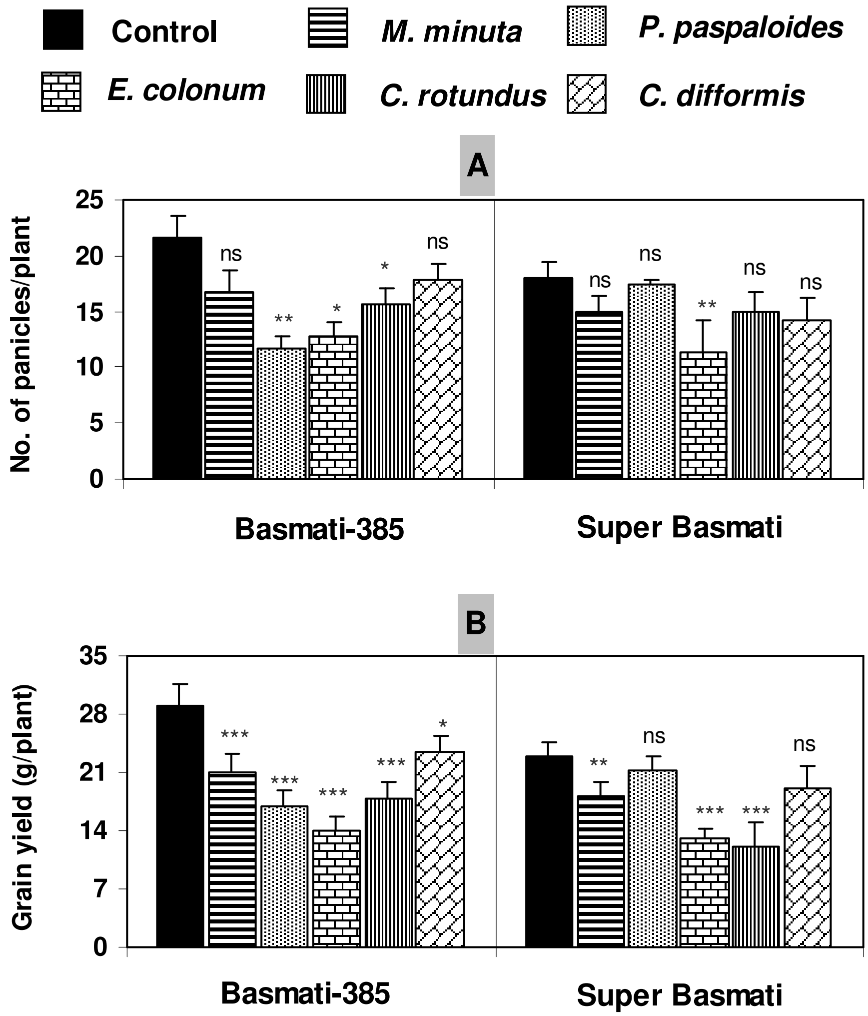

Figure 5. Effect of weeds on yield of rice varieties. Basmati-385 and Super Basmati. Bars denote standard errors of the means. *, ** and *** show significant difference from control at P ≤ 0.05, 0.01 and 0.001, respectively, as determined by t-test; ns, non-significant.

C. difformis (Figure 5B). Super Basmati proved a better competitor to some weeds for this parameter. The effect of *P. paspaloides* and *C. difformis* interference was non-significant. Maximum losses of 42% in grain yield were recorded due to *E. colonum* interference (Figure 5B and 6C). Amongst the two rice cultivars, maximum yield losses (56%) in Basmati-385 were induced due to *E. colonum* interference. Rice yield losses had previously been reported to range between 30 and 100% under high densities of *Echinochloa* spp. (Malik and Moorthy, 1996). Similarly, Kim et al. (1998) also reported 60% reduction in crop yield by *Echinochloa* sp. Comparative growth studies of *Echinochloa* spp. and rice in monoculture indicated that the dark respiration rate of *Echinochloa* spp. was considerably lower than that of rice. Such weeds appeared to be superior to rice in efficiently utilizing the environment and producing higher biomass due to their pathway of photosynthesis. In this study, *C. rotundus* caused maximum yield losses of 42% in Super Basmati. Previously, it has been shown to cause serious problems in rice and other crops in many countries than any other weed, hence regarded as the world's worst weed (Holm et al., 1977; Javaid et al., 2007). According to Keeley (1987), yield losses reach up to 89% in *Allium sativum* L., 62% in *Abelmoschus esculentus* (L.) Moench, 39 to 50% in *Daucus carota* L., and 35% in *Brassica oleracea* L. due to *C. rotundus*. Although some herbicides can control *C. rotundus* adequately, adverse environmental factors and weed growth stages at the time of application have caused poor control (Grichar et al., 1992). This study concludes that *E. colonum* was the most competitive weed and it resulted in the highest yield losses in rice.

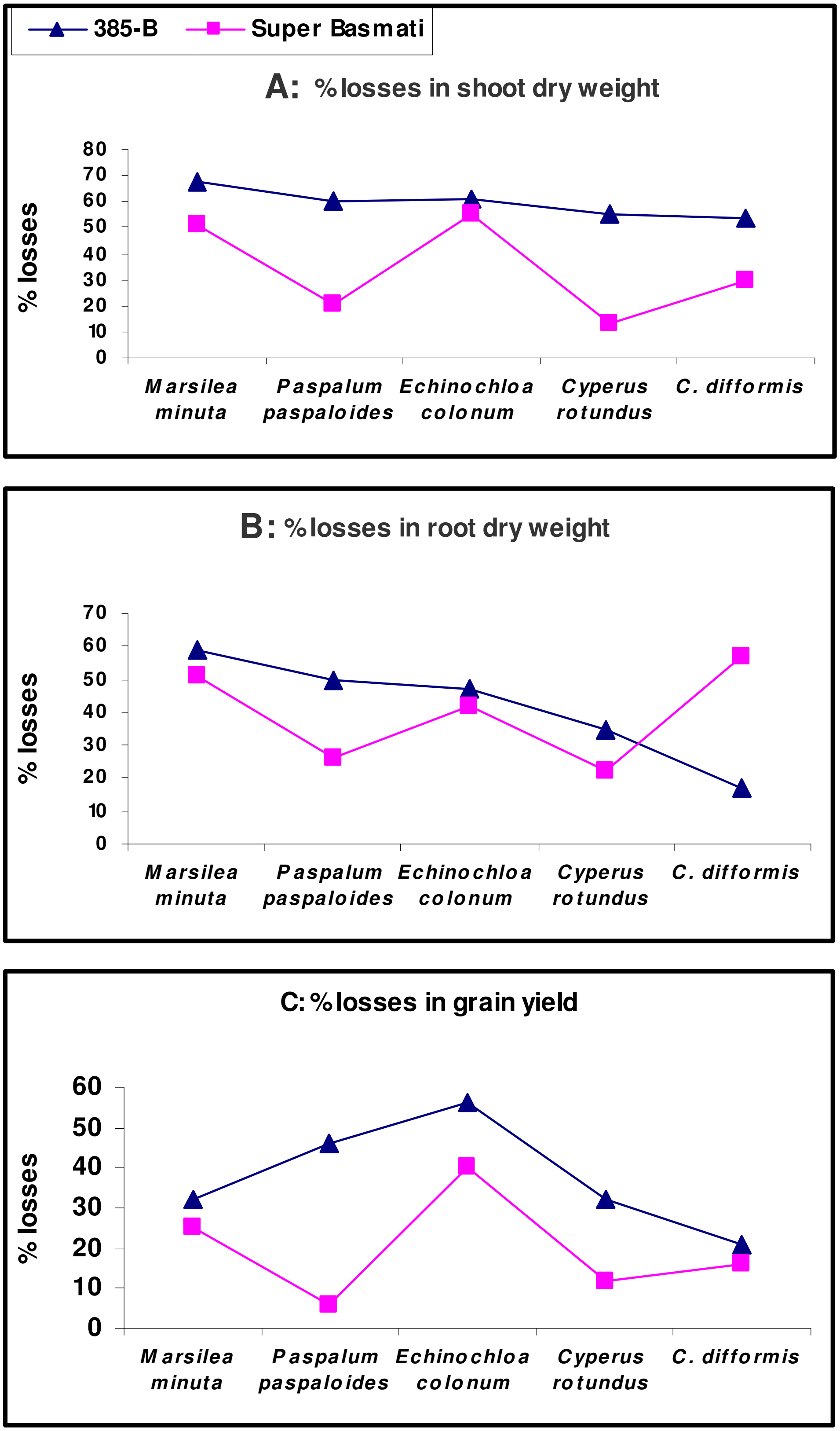

Figure 6. A to C: Percentage losses in shoot and root dry biomass, and grain yield in rice varieties Basmati-385 and Super Basmati, due to weed's competition.

Also, Super Basmati tolerated weeds than Basmati-385.

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