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Production potential of rice as affected by varying population densities of barnyard grass

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ABSTRACT

An experiment was conducted to study the production potential of rice under varying population densities of barnyard grass (*Echinochloa crusgalli*). There was a significant reduction in plant height, dry matter production as well as in yield by rice plant with increasing population density of barnyard grass from 25 plants/m^2 to 250 plants/m^2 because weed plants compete for growth factors like light, nutrients and space, *etc.* The reduction in dry matter was to the tune of 35.76, 32.26 and 35.80% in 250 plants of barnyard grass as compared to pure rice crop in 2005 and 52.11, 45.56 and 44.41% in 2006, respectively. A decreasing trend in panicle length, number of grains per ear, 1000 grain weight, grain and straw yield were observed as plant density of barnyard grass increased from 25 plants/m^2 to 250 plants/m^2 during both the years of investigations. At higher densities of barnyard grass, there was a gradual increase in dry matter production. Hence there was more suppression of rice crop at higher weed densities which resulted in significant reduction in grain yield of rice crop.

Key words: Rice, *Echinochloa crusgalli*, Yield, Production potential.

As the rice crop has assumed a unique position in the farm economy of Punjab state, it will be worthwhile to assess the interaction of this crop with the environment along with the weeds in this crop. The domestication of rice by man must rank one of the most important events of history because it has become the staple food of majority of the world population. The area under rice during 2006-07 in Punjab was 26.47 lakh hectares and its production was 104.37 lakh tonnes. Average yield of rice in India and Punjab during 2006 was 2.10 and 3.86 tonnes per hectare, respectively (Anonymous, 2008).

On global front, India has the largest area under rice cultivation, but falls behind China in terms of volume of production. In the past 50 years, Indian rice production has nearly tripled with the introduction of semidwarf modern varieties as part of the green revolution technology package (Mohanty, 2009). Total global utilization of rice is projected to increase from 376 million metric tonnes in 1996 to 435 million metric tonnes by 2010. In India, rice is cultivated on an area of 43.7 mha which produce 91.8 million metric tonnes. National average productivity is approximately 2 tonnes/ha which is 1/3rd of the global productivity (6.1 tonnes/ha) (Shivay and Kumar 2009).

Wild rice (*Echinochloa colona*) and barnyard grass (*Echinochloa crusgalli*) are two main weeds growing in association with other annual grasses, sedges and annual broad leaf weeds. The extent of yield reduction due to weeds is around 20-25 per cent in transplanted rice, 30-35 per cent in direct seeded puddled rice and over 50 per cent in direct seeded upland rain fed rice. If major weeds of this crop are controlled, then there may be a definite increase in yield. This study was under taken, to evaluate the effect of different plant populations of *Echinochloa crusgalli* on growth and yield of rice.

MATERIALS AND METHODS

Field experiment was conducted at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during the *kharif* season of 2005 and 2006. Ludhiana is situated at 30^{0}56' N latitude and 75^{0}48' longitudes, at an altitude of 247m above mean sea level. The temperature during summer goes as high as 45-47^{0}C while in winter it touches freezing. The average annual rainfall at ludhiana is 705 mm, 75 per cent of which is received during south-west monsoon from July to September. The soil of the experimental site was sandy loam, had normal soil reaction and electrical conductivity, low in organic carbon and available N, medium in available P and K.

The experiment consisted of 60 plots of 10 treatments. The treatment, comprised of 0, 25, 50, 75, 100, 125, 150, 200 and 250 plants of *E. crusgalli* /m^2 in rice and $T_{max,}$ i.e. pure *E. Crusgalli* weed plot. The experiment was laid out in randomized block design with six replications. Rice variety *PR-116* was transplanted at 20 cm row spacing and 15 cm plant spacing (33 hills/m^2) on 18 and 20 June during

2005 and 2006, respectively. The crop was served with 50 kg of N, 12 kg of P_2O_5 and 12 Kg of K_2O per acre of which 1/3 of nitrogen and whole of P and K was applied before the last puddling. The remaining dose of nitrogen was broadcasted in two splits, one three weeks after transplanting and the last three weeks afterwards.

The field was charged with *Echinochloa crusgalli* seed according to the requirement of weed population in treatments. In T_{max}, only weed seed was sown and in T_0 (pure rice crop) no weed seed was added. The population of weed i.e. *Echinochloa crusgalli* was manually counted after 15 days of transplanting and thinning was done thereafter for maintaining different weed populations as per requirement.

Periodic plant height (cm) of rice crop was measured throughout the crop growing seasons for both the years. Ten plants from each plot were selected randomly and plant height was determined from soil surface up to the base of the upper fully developed leaf plant samples were taken periodically throughout the crop growth season for dry matter production. The samples were oven dried at 70^0C till a constant weight was reached and weighed for dry matter and data presented in q/ha. Leaf area index was recorded with the help of calibrated plant canopy analyzer (LICOR-make, Model LAI 2000). Similarly the plant height and dry matter of *E. crusgalli* was also recorded.

At the time of harvest yield contributing characters were recorded. For panicle length, ten plants were selected from each plot and value were averaged to get a single representative value. Number of grains per panicle were counted from selected 10 panicles and averaged. Grain weight of thousand grains was noted from each plot for 1000 grain weight. The spikelet sterility for each treatment was observed from the number of total grains and unfilled grains per panicle and finally grain and straw yield was calculated for each plot and it was converted into q/ha for presentation. Similarly, biometric observations were also recorded in the second year of investigation i.e. 2006.

RESULTS AND DISCUSSION

Effect on plant height

Analysis of variance showed significant differences in plant height of rice recorded periodically in relation to weed population densities (Table 1).Throughout the crop season, maximum plant height was observed in pure rice plots while the minimum height was observed where the density of *Echinochloa crusgalli* was maximum i.e. T_{250} treatment. Generally plant height showed increasing trend from 60 to 90 days and up to harvest. At 60 DAS, five treatments i.e. from T_0 to T_{100} were statistically at par with each other but superior to rest of the treatments during year 2005. In the year 2006, three treatments i.e. T_0, T_{25} and T_{50} were at par with each other but superior than all other weed population treatments. As population of weed goes beyond 100 plants/m^2 there was a significant reduction in plant height of rice plant because weed plants they compete for growth factors like light, nutrients and space *etc.* Similar results were also reported by Walia *et.al* (2001).

Table 1. Periodic plant height (cm) of rice under different population densities of *Echinochloa crusgalli* during 2005 and 2006

Treatment	60 DAT		90 DAT		At Harvest	
	2005	2006	2005	2006	2005	2006
T_0	58.3	67.0	72.3	83.8	78.8	86.6
T_{25}	56.5	62.2	71.3	78.2	76.0	81.4
T_{50}	54.0	63.0	66.7	78.6	78.4	80.2
T_{75}	55.3	49.8	67.7	76.6	72.1	81.6
T_{100}	51.8	48.6	62.6	75.8	70.9	79.6
T_{125}	49.0	45.6	64.0	75.2	67.3	77.4
T_{150}	38.7	40.4	59.3	75.0	64.6	77.0
T_{200}	36.5	41.6	61.3	69.2	62.2	71.6
T_{250}	37.3	38.4	55.0	63.0	60.7	68.6
T_{max}	-	-	-	-	-	-
LSD(P=0.05)	8.2	11.5	4.8	5.5	6.8	5.1

T - Treatments, comprising number of *E. crusgalli* plants/m^2 **:** DAT - Days after transplanting

Effect on leaf area index

Leaf area index (LAI) is one of the most important factors that influence interception of radiation, transpiration and ultimately photosynthesis. Leaf area development and maintenance are considered to be key factor for maximum dry matter production and yield. Leaf area index differed significantly at observations made on 35, 60 and 80 days after transplanting (DAT). There was a continuous increase in LAI up to 60 DAT but thereafter, a decrease was noticed. Maximum leaf area index for pure rice crop was found to be 4.44 and 4.27 at 60 DAT during the year 2005 and 2006, respectively (Table 2). This period depicts the maximum vegetative growth period of the crop. As the crop was approaching maturity, the leaf area index decreased considerably. These findings are in agreement with the findings of Chang *et al* (2005).

The treatments with higher weed densities had higher leaf area index and maximum LAI among weed population treatments was recorded in T_{max} i.e. pure *Echinochloa crusgalli* plots at all observational stages during both the years of investigation. This higher LAI in high weed density plots caused an increasing light extinction which reduced the tillering of rice, shortened the tillering period and increased tiller mortality rate. These results are in agreement with the findings reported by Graf *et al* (1990).

Effect on dry matter accumulation

The dry matter accumulation of rice was affected significantly by weed competition at all stages of observation (Table 3). Dry accumulation by the crop decreased with increase in weed population, maximum dry matter was accumulated by the crop at 65 to 95 DAT, which is the grand growth phase of the crop during both years of study. Except at 35 DAT, pure rice crop recorded significantly higher dry matter than rest of the weed population treatments at all stages during both the years of study. The reduction in dry matter was to the tune of 35.76, 32.26 and 35.80% in T_{250} as compared to pure rice crop in 2005 and 52.11, 45.56 and 44.41 per cent in 2006. The dry matter accumulation depends upon the amount of radiation received, the area of intercepting surface, the efficiency with which the inter-cepted radiation is utilized in the production of dry matter and loss of dry matter due to physiological, pathological and weed competition factors. This much reduction in dry matter accumulation is due to severe competition posed by *E. crusgalli* to the rice crop. These findings are also supported by Graf and Hill (1992). They reported that even at a density of 100 rice plants/m^2, 10 plants of *E. crusgalli*/m^2 cause a yield loss of about 50 per cent.

Effect on yield and yield contributing characters

A decreasing trend in panicle length, number of grains per ear, 1000 grain weight, grain and straw yield was observed as plant density of *E. crusgalli* increased from 25 plants/m^2 to 250 plants/m^2 during both the years of investigations (Table-4). During 2005, the panicle length

Table 2. Leaf area index (LAI) of rice under different population densities of *Echinochloa crusgalli* during 2005 and 2006

Treatment	35 DAT		60 DAT		80 DAT	
	2005	2006	2004	2006	2005	2006
T_0	2.98	2.30	4.44	4.27	3.87	3.45
T_{25}	3.30	2.61	4.30	4.24	3.16	3.28
T_{50}	3.18	2.67	4.40	4.30	3.34	3.27
T_{75}	3.28	2.80	4.35	4.33	3.17	3.11
T_{100}	3.25	3.24	4.70	4.55	3.55	3.49
T_{125}	3.35	2.97	4.65	4.81	3.61	3.72
T_{150}	3.47	3.31	4.75	4.81	3.41	3.80
T_{200}	3.58	3.62	4.85	4.82	3.78	3.73
T_{250}	3.65	3.53	5.15	5.12	3.91	4.06
T_{max}	5.23	5.17	5.60	5.49	4.27	4.17
LSD(P=0.05)	1.47	0.32	0.31	0.22	0.18	0.21

T - Treatments, comprising number of *E. crusgalli* plants/m^2 **,** DAT - Days after transplanting

Table 3. Dry matter production (q/ha) of rice under different population densities of *Echinichloa crusgalli* during 2005 and 2006

Treatment	35 DAT		65DAT		95 DAT		At harvest	
	2005	2006	2005	2006	2005	2006	2005	2006
T_0	27.9		67.4	66.2	130.5	119.4	151.1	148.6
T_{25}	26.1	24.7	60.1	60.5	118.1	106.9	137.8	129.7
T_{50}	27.2	23.2	57.5	57.3	120.3	93.3	132.3	111.9
T_{75}	27.0	23.8	54.0	51.6	117.6	94.0	130.6	112.3
T_{100}	26.3	20.4	52.9	50.1	116.8	90.3	125.8	112.7
T_{125}	26.0	20.8	53.2	49.9	116.1	91.7	126.3	109.1
T_{150}	25.3	20.2	51.8	43.7	111.0	74.1	120.5	100.6
T_{200}	23.8	19.9	47.9	35.1	103.2	67.8	111.0	93.2
T_{250}	22.6	19.4	43.4	31.7	88.4	65.0	97.0	82.6
T_{max}	-	-	-	-	-	-	-	-
LSD (P=0.05)	2.1	2.9	4.0	5.1	13.2	5.6	11.2	8.4

T - Treatments, comprising number of *E. crusgalli* plants/m^2, DAT - Days after transplanting

of T_o, T_{25}, T_{50} and T_{75} were statistically at per with each other but significantly superior to rest of the treatments whereas in the year 2006, all weed population treatments recorded significantly less panicle length as compared to pure rice treatment. T_0 and T_{25} treatments were statistically at par with each other in producing number of grains per panicle but significantly superior to rest of the treatments during both the years of study. These findings were also supported by the findings of Dhaliwal *et al* (1997).

Similar results were also obtained in case of 1000 grain weight where T_0 and T_{25} were statistically at par with each other during 2005 but in 2006, pure rice crop recorded significantly higher 1000 grain weight than all other treatments however the highest 1000-grain weight was recorded in pure rice plot during both the years of study.

were statistically at par with each other during 2005 but in 2006, pure rice crop recorded significantly

Table 4. Yield and yield contributing character of rice under different population densities of *Echinochloa crusgalli* during 2005 and 2006

Treatment	Panicle length (cm)		Grain/ear (number)		1000 grain weight (g)		Spikelet sterility (%)		Grain yield (q/ha)		Straw yield (q/ha)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
T_0	24.5	24.3	180	158	24.5	24.5	6.5	6.7	63.1	60.1	131.1	122.0
T_{25}	24.8	21.5	159	134	23.7	20.4	9.9	10.9	44.4	30.8	102.0	90.9
T_{50}	22.5		133	122	22.3	20.3	5.2	11.4	34.6	28.6	87.0	86.4
T_{75}	23.9	22.4	131	124	21.5	21.5	10.3	11.2	23.4	22.9	78.9	86.0
T_{100}	22.4	21.5	123	120	20.9	20.7	9.8	11.3	20.2	19.9	65.4	75.7
T_{125}	22.0	21.0	120	121	20.3	20.2	11.5	12.7	16.4	20.1	58.2	68.1
T_{150}	21.6	22.2	116	119	20.5	20.9	11.0	13.7	14.8	19.5	50.2	58.8
T_{200}	21.8	21.4	113	116	19.9	20.0	12.7	12.2	14.9	16.8	43.7	52.0
T_{250}	20.3	20.4	108	111	20.3	19.2	21.0	14.9	10.8	11.8	23.8	25.7
T_{max}	-	-	-	-	-	-	-	-	-	-	-	-
LSD(P=0.05)	2.3	1.23	27	15	1.4	1.8	6.6	1.7	8.5	4.8	20.0	11.6

T - Treatments, comprising number of *E. crusgalli* plants/m^2, DAT - Days after transplanting higher 1000 grain weight than all other treatments however the highest 1000-grain weight was recorded in pure rice plot during both the years of study.

Spikelet sterility showed an increasing trend with increasing in population density of weeds (Table 4). However, lowest spikelet sterility was observed in pure rice treatment (T_0), where there was no competition between the crop and weed.

Effect on grain yield

The decrease in panicle length, number of grains per panicle and 1000-grain weight contributed less production of yield with increasing population density of *E. crusgalli* from 25 plants/m^2 to 250 plants/m^2. However maximum grain yield was recorded in weed free treatment (T_0). Where there is no completion for growth factors between the rice plant and weed plants. A significant reduction in grain yield was recorded by increasing population density of weeds to 25 plants/m^2 i.e. 63.08 q/ha to 44.38 q/ha in 2005 and 60.1 q/ha to 30.8 q/ha in 2006 as compared to pure rice crop. The treatments T_{50}, T_{75}, T_{100}, T_{125},T_{150},T_{200} and T_{250} record a yield reduction of 45.18, 62.87, 67,89, 74.03, 76.55, 76.34 and 82.83 percent during 2005 and 51.98, 61.89, 66.88, 66.55, 67.55, 72.05 and 80.37 percent during the second year of study. At higher densities of *E. crusgalli,* there was a gradual increase in dry matter production. Hence there was more suppression of rice crop at higher weed densities which resulted in significant reduction in grain yield of rice crop (Table 4). These findings are also supported by findings of Walia and Singh (2005).

Effect on plant height and dry matter

The plant height showed an increasing trend as population density of *Echinochloa crusgalli* increased from 25 plants to 250 plants/m^2 at all the observational stages studied except after 60 DAT (Table 5) during both the years of study. However the lowest plant height was recorded in T_{25} and maximum in T_{max} treatment i.e. pure *Echinochloa crusgalli* treatment. Similarly dry matter accumulation by *E. crusgalli* increased with increasing its population and highest amount of dry matter was recorded under pure weed plot i.e. T_{max} at all the observation stages studied during both the years.

Table 5. Periodic plant height (cm) of *Echinochloa crusgalli* under its varying population densities during 2005 and 2006

Treatment	60 DAT		90 DAT		At harvest	
	2005	2006	2005	2006	2005	2006
T_{25}	42.6	41.6	104.0	103.6	116.0	107.8
T_{50}	54.3	55.7	119.0	110.0	129.0	116.8
T_{75}	61.3	58.0	119.0	115.2	131.0	119.4
T_{100}	77.9	85.7	132.0	107.2	149.0	118.4
T_{125}	87.5	88.9	116.5	106.0	129.7	107.4
T_{150}	92.5	90.6	103.0	114.8	116.2	114.0
T_{200}	82.1	81.2	105.5	111.2	119.7	115.5
T_{250}	79.6	83.2	112.5	108.4	120.2	113.5
T_{max}	81.3	84.2	125.5	121.0	142.0	138.4
LSD(P=0.05)	6.1	9.9	7.3	5.5	6.8	5.1

T - Treatments, comprising number of *E. crusgalli* plants/m^2, DAT - Days after transplanting

Table 6 Dry matter production (q/ha) by *Echinochloa crusgalli* under its different population densities during 2005 and 2006

Treatment	35 DAT		65 DAT		95 DAT		At harvest	
	2005	2006	2005	2006	2005	2006	2005	2006
T_{25}	18.6	12.1	48.1	36.1	67.2	55.8	70.3	60.5
T_{50}	16.5	16.2	52.3	40.3	78.8	60.6	85.4	68.3
T_{75}	18.8	16.6	60.5	48.5	82.7	69.5	87.9	77.2
T_{100}	22.3	22.8	80.4	68.4	111.2	89.7	117.5	99.4
T_{125}	36.8	27.3	112.7	100.7	140.6	121.7	142.7	131.3
T_{150}	41.4	31.9	108.6	96.6	141.1	117.9	146.9	127.6
T_{200}	68.8	59.3	130.4	118.4	156.2	141.1	164.1	155.8
T_{250}	70.2	60.7	160.4	148.4	168.7	171.7	175.8	186.4
T_{max}	74.1	64.6	165.9	153.9	195.1	176.6	216.9	191.2
LSD(P=0.05)	7.8	6.8	13.8	12.4	14.4	9.8	15.5	12.9

T - Treatments, comprising number of *E. crusgalli* plants/m^2, DAT - Days after transplanting

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