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Weed dynamics and production efficiency of rice-based cropping system

Monika Soni*, V.B. Upadhyay and Poonam Singh

Department of Agronomy Jawaharlal Nehru Krishi Vishwavidhyalay, Jabalpur, Madhya Pradesh 482 004

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ABSTRACT

Field experiments were conducted during 2007-08 and 2008-09 to study weed dynamics and production efficiency under diversified and intensified rice based cropping systems in Kymore Plateau and Satpura Hills Zone of Madhya Pradesh. Among the all 12 rice based cropping systems under *Kharif*, in rice *Echinochloa crusgalli* was the most dominating weed contributing 32.8% of total weed intensity at most critical period (25 DAT) while *Monochoria vaginalis* at harvest stage (18.8%). During *Rabi*, relative density of weeds varied between different crops. In early (30.2 to 43.3%) and at harvest stage (10.1 to 46.8%) *Medicago denticulata* was found to be more serious weed almost in all *Rabi* crops grown under different cropping systems but in onion and garlic *Portulaca oleracea* having higher intensity at harvest stage (45.2%). The *Portulaca* spp. predominantly infested to all summer crops at early (41.5 to 54.6%) and harvest stage (37.2 to 44.1%). In rice varieties the weed intensity and biomass ranged from 229.0 to 254.2/m^2 and 1.0 to 1.15 t/ha under different crop systems respectively. During *Rabi*, weed intensity was higher in vegetable pea (207.3/m^2) and weed biomass was higher berseem (0.71 t/ha). During summer season, the weed intensity was maximum (156.4/m^2) in okra which resulted into the highest weed biomass production (0.67 t/ha). Both rice and wheat crops grown under rice–wheat system require large quantity of irrigation water which is favourable to build up a typical weed infestation problem. All diversified and intensified cropping systems significantly led to record higher production efficiency (83.13kg/ha/day to 57.05kg/ha/day) beneficial to minimize the serious challenges posed by the weeds as compared to both existing cropping systems *viz.*, rice-wheat (45.63kg/ha/day) and rice-chickpea (39.49kg/ha/day).

Key words: Diversification and intensification, Production efficiency, Rice-based cropping systems,Weed dynamics

Rice-wheat and rice-chickpea cropping systems are predominant in Kymore Plateau and Satpura Hills agroclimatic zone of Madhya Pradesh. Both rice and wheat crops require large quantity of irrigation water which favours build up of weed infestation in such areas. Therefore, it is imperative to make a systemic research effort for achieving twin objectives of higher production efficiency with efficient water use and weed control through suitable crop diversification. Present investigation was aimed to evaluate the relative performance of twelve rice-based cropping systems of Kymore plateau and Satpura hills agro-climatic zone under assured irrigated production system. These cropping systems were compared for their production efficiency and weed dynamics.

MATERIALS AND METHODS

Field experiment was conducted on diversification and intensification of cropping system over existing rice-wheat and rice-chickpea cropping systems during the year 2007-08 and 2008-09 in Jabalpur (M.P.). Jabalpur district is the central part of Madhya Pradesh and it lies between $22^0$49' to $24^0$8' N latitude and $78^0$21' to $80^0$58' E longitudes with an average altitude of 411.78 metres above the mean sea level. The soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction (pH 7.70) with normal EC (0.48 dS/m) and low OC contents (0.68%), medium in available N (266 kg/ha), low in available P (9. 2 kg/ha) and medium in available K (300 kg/ha) contents. The treatments consisted with 12 cropping systems *viz.*, T_1-rice (*Kranti*)-wheat (*GW 273*), T_2-rice (Kranti)- chickpea (*JG 322*), T_3-Hy. rice (*Pro Agro 6444*)-onion (*Pusa Red*)-greengram (*Pusa Vishal*), grain+residue management, T_4-rice (*Pusa Basmati 1*)-berseem fodder seed (*JB 5*), T_5-Hy. rice (*JRH 5*)-potato (*Kufri Sinduri*)-maize (JM 12) cob+fodder, T_6-Hy. rice (JRH 5)-gobhi sarson (*Terri Uttam*)-maize (*JM 12*) cob+fodder, T_7-Hy. rice (*JRH 5*)-vegetable pea (*Arkel*)-sunflower (*PSH 12*), T_8-Hy. rice (*JRH 5*)-potato (*Kufri Sinduri*)-groundnut (*Jyoti*), T_9-Hy. rice (*JRH 5*)-gobhi sarson (*Terri Uttam)*-groundnut+maize 4:2, T_{10}-Hy. Rice (*JRH 5*)-gobhi sarson (*Terri Uttam*)-okra (*Parbhani Kranti*), T_{11}-Hy. rice (*JRH*

***Corresponding author:** monika.soni8@gmail.com

5)-garlic (*G-41*)-maize+cowpea 4:2 rows and T_{12}-Hy. rice (*Pro Agro 6444*)-marigold (*African Giant*)-maize (*JM 12*) cob+fodder. These treatments were tested in a randomized block design with 4 replications. In *Kharif* season all varieties of rice were transplanted. Recommended package of practices for all the crops in system were followed. Weeds were controlled in rice with the use of rice rotary weeder at 20 and 40 DAT. In wheat weeds were controlled with the use of hand weeding at 30 DAS. In irrigated chickpea, green pea, gobhi sarson and marigold weeds were controlled with the use of hand weeding at 30 DAS. Weed control in onion and garlic was made with the use of hand weeding at 20 and 40 DAT. Berseem weeds were controlled with one hand weeding before allowing the crop for seed production. In potato, weeds were controlled with hand weeding followed by earthing at 20 DAS and with hand weeding only at 50 DAS. In sunflower, green gram and okra weeds were controlled with the use of hand hoe at 20 DAS fallowed by a hand weeding at 40 DAS. In maize and groundnut first hand weeding was done at 20 DAS immediately fallowed by earthing and again one hand weeding was done at 30 DAS.

Various observations were recorded on pattern of weed infestation in various crops under different crop systems at 25 days after transplanting (DAT) days after sowing (DAS) and at harvest. After this, weed dynamics of all cropping systems were worked out. Production efficiency of all cropping systems was also worked out with the help of following formula:

$$\text{Production efficiency (kg/ha/day)} = \frac{\text{Rice equivalent yield (kg/ha) of a particular crop sequences}}{\text{Total duration of all crop components of the same crop sequence (days)}}$$

RESULTS AND DISCUSSION

Relative weed density in *Kharif* season

In rice, the dominating weeds were *Echinochloa crusgalli (32.8%), Cyperus irria* (22.2%), *Fimbristylis barbata* (13.9%), *Sahima nervosum* (7.0%), *Monochoria vaginalis* (6.3%), *Commelina communis* (5.1%) and *Eclipta alba* (3.2%) with other weeds (9.5%) at 25 DAT. At maturity stage, the relative density of all weeds was changed. The severity of *E. Crusgalli* (7.8%), *C. Irria*/*C. differmis* (10.2%) and other weeds (6.2%) were reduced to great extent. But relative density of *Fimbristylis barbata* (16.3%), *Monochoria vaginalis* (18.8%), *Sahima nervosum* (18.4%), *Eclipta alba* (4.0%) increased at final stage over their relative density at 25 DAT. Typically *Caesulia axillaris* (8.1%) had shown its presence at maturity which was almost nil at early stage (Tible 1).

Relative weed density in *Rabi* season

During *Rabi* season, relative density of weeds varied between different crops. *Medicago denticulata* was found to be more serious weed in almost all *Rabi* crops grown under different crop-sequences. Its relative density was 39.4, 41.7, 30.2, 34.5, 46.9 26.8, and 43.3% in wheat, berseem, onion and garlic, chickpea and vegetable pea, gobhi sarson, potato and marigold, respectively at 25 DAS, which changed as 42.1, 24.4, 10.1, 30.2, 42.4, 9.4 and 46.8%, respectively at maturity stage. It means infestation of this weed declined due to cultivation of berseem, onion and garlic and potato crops. Frequent cuttings for fodder in berseem and earthing as well as cultural practices associated with potato, onion and garlic resulted in decline in its infestation. The late emerged plants of this weed generally made corpet like shape on cropped plots under wheat, gobhi sarson and marigold and thus resulted to its higher weed relative density. *Chenopodium album* and *Melilotus alba* were common weeds in almost all *Rabi* crops. But severity of *Chenopodium album* was much serious in marigold (23.3%), gobhi sarson (19.1%), chick pea and vegetable pea (16.9%), wheat (16.4%), potato (12.7%), onion and garlic (12.6%) and berseem (6.8%), in early stage which decline at maturity 13.5, 10.8, 6.4, 10.4, 6.2, 5.2, and 3.4% respectively. While *Melilotus* spp. severely dominated to wheat (14.3), chickpea and vegetable pea (30.4%) at maturity stage (Table 1). Some of *Rabi* weeds shown their presence with their most associated crops like *Phalaris minor* (4.1%) and *Vicia sativa* (8.4%) in wheat, *Anagallis arvensis* in onion and garlic (3.1%), gobhi sarson (9.1%), potato (8.4%) and marigold (5.4%); *Rumex dentatus* in potato (12.4%), berseem (20.2%) and marigold (6.4%); and *Chichorium intybus* (8.1%) in berseem at maturity. Typically *Portulaca oleracea* infested potato only during *Rabi* in early (36.4%) and at maturity stages (40.4%).

Relative weed density in summer season

In greengram, *Portulaca oleracea, Cyperus* spp., *Echinochloa crusgalli* and other minor weeds contributed to 44.15, 25.49, 10.00 and 10.00% of total weeds, respectively at 25 DAS, while the relative intensity of these weeds deviated as 44.1, 18.2, 18.2 and 19.5%, respectively at maturity. In maize, *Portulaca oleracea, Cyperus* spp., *Trianthima monogyna* and others weeds had relative density of 41.43, 16.42, 13.99, 28.16%, respectively, while relative density of these weeds were 53.17, 15.21, 16.88 and 14.74%, respectively in sunflower at 25 DAS. The relative intensity of these weeds was 51.67, 17.56, 11.29 and 19.48%, respectively in groundnut and okra at this stage. The relative density of all these weeds was changed

Table 1. Relative density of weeds at 25 DAS and maturity of various crops

Crop	Predominant weeds	Relative density (%)	
		At 25 DAS	At maturity
Rice	*Echinochloa crusgalli*	32.8	7.8
	Cyperus iria / C. difformis	22.2	10.2
	Fimbristylis barbata	13.9	16.3
	Sahima nervosum	7.0	18.4
	Monochoria vaginalis	6.3	18.8
	Commelina communis	5.1	10.2
	Eclipta alba	3.2	4.0
	Caesulia axillaris	-	8.1
	Others	9.5	6.2
	Total	100.0	100.0
Wheat	*Medicago denticulata*	39.4	42.1
	Chenopodium album	16.4	10.4
	Melilotus alba	12.8	14.3
	Phalaris minor	6.2	4.1
	Vicia sativa	6.6	8.4
	Others	18.6	20.7
	Total	100.0	100.0
Berseem	*Medicago denticulata*	41.7	24.4
	Trifolium flagiferum	14.3	20.3
	Rumex dentatus	9.6	20.2
	Chenopodium album	6.8	3.4
	Chichorium intybus	6.5	8.1
	Othres	21.1	23.6
	Total	100.0	100.0
Onion & Garlic	*Medicago denticulata*	30.2	10.1
	Portulaca oleracea	28.2	45.2
	Chenopodium album	12.6	5.2
	Anagallis arvensis	10.4	3.1
	Others	18.6	36.4
	Total	100.0	100.0
Chickpea & vegetable pea	*Medicago denticulata*	34.5	30.2
	Melilotus alba	18.4	30.4
	Chenopodium album	16.9	6.4
	Anagallis arvensis	9.8	5.8
	Others	20.4	27.2
	Total	100.0	100.0
Gobhi sarson	*Medicago denticulata*	46.9	42.4
	Chenopodium album	19.1	10.8
	Melilotus alba	14.9	9.4
	Anagallis arvensis	8.3	9.1
	Others	10.8	28.3
	Total	100.0	100.0
Potato	*Portulaca oleracea*	36.4	40.4
	Medicago denticulata	26.8	9.4
	Chenopodium album	12.7	6.2
	Anagallis arvensis	10.6	8.4
	Rumex dentatus	6.8	12.4
	Others	6.7	23.2
	Total	100.0	100.0
Marigold	*Medicago denticulata*	43.3	46.8
	Chenopodium album	23.3	13.5
	Rumex dentatus	8.8	6.1
	Anagallis arvensis	8.4	5.4
	Others	16.2	28.2
	Total	100.0	100.0
Greengram	*Portulaca oleracea*	54.6	44.1
	Cyperus spp.	25.5	18.2
	Echinochloa crusgalli	10.1	18.2
	Others	10.1	19.5
	Total	100.0	100.0
Maize	*Portulaca oleracea*	41.5	37.2
	Cyperus spp.	16.5	10.6
	Trianthima monogyna	13.8	28.4
	Others	28.2	23.8
	Total	100.0	100.0
Sunflower	*Portulaca olercea*	53.2	41.4
	Trianthima monogyna	16.7	20.2
	Cyperus spp.	15.3	9.4
	Others	14.8	29.0
	Total	100.0	100.0
Groundnut & okra	*Portulaca oleracea*	51.6	40.1
	Cyperus spp.	17.6	16.8
	Trianthima monogyna	11.3	20.2
	Others	19.5	22.9
	Total	100.0	100.0

as 37.2, 10.6, 28.4 and 23.8% in maize, 41.4, 20.2, 9.4 and 29.2% in sunflower and 40.1, 16.8, 20.2 and 22.9% in groundnut and okra, respectively at their maturity stages. Similar findings were reported by Singer *et al*. 2000 and Singh *et al*. 2005.

Weed intensity and weed biomass

During *Kharif* season, total weed population ranged from 229.0/m^2 in Hy. rice-marigold - maize cob+fodder (T_{12}) to 254.2 /m^2 in Hy. rice-potato-groundnut (T_8). The weed population did not vary much due to the effect of different rice varieties. The weed biomass also varied from 1.00 t/ha in Hy. rice- gobhi sarson - groundnut+maize 4:2 (T_9) to 1.15 t/ha in rice - marigold - maize cob+fodder (T_{12}). The weed biomass was also almost identical in all the varieties (Table 2).

During *Rabi* season, the weed intensity was minimum (93.9 to 103.0/m^2) in potato crop grown under two different cropping systems, hence the lowest weed biomass (0.13 to 0.14 t/ha) was recorded in both potato fields. Both onion and garlic faced almost similar kind of weed-infestation, which were higher as compared to potato, hence, these resulted into higher weed biomass (0.25 to 0.26 t/ha) and 105.3 and 106.0 weeds/m^2 weed intensity. In gobhi sarson weed population ranged from 167.9 to 184.0/m^2 with weed dry weight of 0.37 to 0.41 t/ha. The weed density were 165.0, 189.1, 183.4, 207.3 and 183.0 weeds/m^2 in wheat chickpea, berseeem, vegetable pea and marigold, respectively, but weed biomass were 0.42, 0.51, .071, 0.61 and 0.50 t/ha in respective crops.

During summer season, okra allowed maximum infestation of weeds (156.4/m^2) with the highest weed biomass (0.65 t/ha). Sunflower and green gram had weed intensity of 134.9 and 132.0/m^2 and produced weed biomass of 0.53 and 0.46 t/ha, respectively. Weed intensity ranged from 120.4 to 122.1/m^2 in maize with dry matter weight of 0.50 to 0.55 t/ha. Groundnut had the weed intensity of 126.4/m^2 with minimum weed biomass of 0.37 t/ha. When cowpea and groundnut intercropped with maize, maize had weed intensity of 116.9 and 107.0/m^2, respectively and produced weed biomass of 0.42 and 0.42 t/ha, respectively. The inter cropping of groundnut and cowpea with further maize reduced the weed infestation over sole maize.

Production efficiency

Among different cropping systems tested, Hy. rice *JRH 5*-garlic-maize + cowpea (fodder) markedly registered the highest production efficiency (83.1 kg/ha/day). The next best cropping system was Hy. rice *JRH 5* - potato- groundnut (69.7 kg/ha/day) closely followed by Hy. rice *JRH 5* - potato - maize (65.8 kg/ha/day). Remaining

Table 2. Weed intensity, weed biomass and production efficiency at maturity stage under different cropping systems (mean of two years)

Cropping system		Weed intensity (no/m^2)			Weed biomass (t/ha)			Production efficiency (kg/ha/year)
		Kharif	*Rabi*	Summer	*Kharif*	*Rabi*	Summer	
T_1	Rice (*Kranti*) - wheat (*GW 273*)	248.9	165.0	-	1.10	0.42	-	45.6
T_2	Rice (*Kranti*) -chickpea (*JG 322*)	236.9	189.1	-	1.06	0.51	-	39.5
T_3	Rice (*Pro Agro 6444*) - onion (*Pusa red*) – greengram (*Pusa Vishal*) G+R	241.0	105.3	132.0	1.13	0.25	0.46	55.2
T_4	Rice (*Pusa Basmati*) - berseem (*JB 5*) fodder + seed	249.4	183.4	-	1.01	0.71	-	57.0
T_5	Rice (*JRH 5*) - potato (*Kufri Sinduri*) -maize (*JM 12*) cob + fodder	241.1	93.9	122.1	1.14	0.13	0.55	65.8
T_6	Rice (*JRH 5*)- gobhi garson (*Terri Uttam*) – maize (*JM 12*)	230.9	191.7	120.4	1.13	0.39	0.50	45.8
T_7	Rice (*JRH 5*) – vegetable pea (*Arkel*) -sunflower (*PSH 12*)	248.1	207.3	134.9	1.07	0.61	0.53	48.3
T_8	Rice (*JRH 5*) - potato (*Kufri Sinduri*) -groundnut (*Jyoti*)	254.2	103.0	126.4	1.05	0.14	0.37	69.7
T_9	Rice (*JRH 5*) - gobhi sarson (*Terri Uttam*) – Groundnut (*Jyoti*) + Maize (*JM 12*) 4:2 row	253.9	184.0	107.0	1.00	0.41	0.42	51.3
T_{10}	Rice (*JRH 5*) - gobhi sarson (*Terri Uttam*) – okra (*Parbhani Kranti*)	245.9	167.9	156.4	1.12	0.37	0.65	51.6
T_{11}	Rice (*JRH 5*) - garlic (*G-41*) - maize (*JM 12*) + cowpea (Local) 4:2 row	241.8	106.0	116.9	1.01	0.26	0.42	83.1
T_{12}	Rice (*Pro Agro 6444*) - marigold (*African Giant*) - maize (*JM 12*) cob + fodder	229.0	183.0	120.5	1.15	0.50	0.48	54.0
	LSD (P=0.05)	0.484	0.398	0.394	0.18	0.03	0.03	0.60

diversified intensive cropping systems recorded production efficiency ranging from 45.8 to 57.05 kg/ha/day, which were higher than existing cropping systems *viz.*, rice - wheat (45.6 kg/ha/day) and rice - chickpea (39.5 kg/ha/day). Beseem being a high yielding crop during *Rabi* season resulted into handsome production efficiency of 57.1 kg/ha/day under rice '*Pusa Basmati 1*' - berseem fodder + seed system, although rice '*Pusa Basmati 1*' was low yielder during *Kharif* season (Table 2). Similar high values of production efficiencies with the inclusion of high yielding crops under existing cropping systems have been also reported by several other workers from different agro-climatic conditions. (Sharma and Kewat 1999, Yadav *et al.* 2000, Chouhan *et al.* 2001, Kharub *et al.* 2003.

Hence, it can be concluded that relative weed density and weed-flora differed from crop to crop from early stage to maturity of crops. Thus, infestation of severe weeds *viz.*, *Phalaris minor* in wheat, *Chichorium intybus* and *Rumex* spp. and *Medicago denticulata* in berseem could be minimized by intensified and diversified them with other crops with higher production efficiency.

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