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Integrated weed management in garlic with and without rice straw mulch

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ABSTRACT

A field experiment was conducted at AICRP on Weed Management Farm, BACA, AAU, Anand Gujarat during two consecutive *Rabi* season of 2016-17 and 2017-18 on loamy sand soil to study the effect of integrated weed management in garlic with and without rice straw mulch. The experiment was laid out in Split Plot design (SPT) with three replications. Rice straw mulch 5.0 t/ha applied after planting in conjunction with either application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP or tank mix application of pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE recorded significantly lower density and dry weight of weeds at harvest with higher weed control efficiency (91.9 and 85.9%, respectively), bulb weight (17.3 and 14.0 g/bulb, respectively), bulb yield of garlic (8.83 and 7.91 t/ha, respectively) along with the highest net return and B:C ratio.

INTRODUCTION

Garlic is one of the oldest cultivated spices and in production next to onion. It is cultivated commercially throughout the tropical and subtropical region of the world. The major garlic growing states are Gujarat, Uttar Pradesh and Madhya Pradesh, of these Madhya Pradesh ranks first in area (0.6 lakh ha) and production (2.7 lakh tonnes) with productivity of 4.5 t/ha (Anonymous 2014). Garlic is highly vulnerable to weed infestation due to its delay in emergence, slow initial growth habit, non-branching character, sparse foliage as well as fibrous root system (Rahman *et al*. 2012). Based on the study Kropff and Joije (1987) concluded that the density of weed species per unit area is not the only factors which cause the yield loss but also the time of the growth of weeds during the growing season would be more important. This leads to flourish the weeds and reduce the bulb yield to the tune of 61.77% under weedy plots as compared to hand weeded plots (Singh and Nandal 2002).

Looking to the yield losses, it is necessary to manage the weeds during initial growth stages either manually or by other practices. Mechanical methods required more labour and in present situation paucity of timely availability as well as high wages leads to choose alternative option. Under such circumstances herbicides considered as a boon to farmers in region where the limited availability of labours and high wages. Further, garlic is sensitive to moisture stress and high temperature responsible for drastic reduction in yield. Mulching with crop residues may held in conservation of soil moisture which reduce the moisture stress and also showed suppression effect on weeds. Umar *et al*. (2000) also reported that rice straw mulch has a capacity to suppress the growth of the weed effectively in garlic and onion besides maintain the soil moisture as well as congenial condition for better growth of the crop labours and high wages. The present investigation was planned to study the effect of integrated weed management practices with and without rice straw mulch on weeds, yield attributes and yield of garlic.

MATERIALS AND METHODS

A field experiment was conducted at AICRP-Weed Management Farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during two consecutive *Rabi* season of the year 2016-17 and 2017-18 on loamy sand soil to study the effect of rice straw mulch and weed management practices on weeds, yield attributes and yield of garlic. The soil of experimental field was low in available nitrogen and medium in available phosphorus and high in potassium with pH 7.91. Sixteen treatment combination comprising two levels of rice straw mulch, *viz*. without mulch and with mulch 5 t/ha were allotted to main plot and eight weed management practices, *viz*. pendimethalin 500 g/ha PE *fb* HW at 60 DAP, pendimethalin 1000 g/ha PE,

oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP, oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP, pendimethalin 500 g/ha + oxyfluorfen 120 g/ha PE (tank-mix), pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (tank-mix), hand weeding at 30 and 60 DAP and weedy check were relegated in sub-plot under split-plot design with three replications. In treatment weeds were removed by manual uprooting without disturbing the mulch. The garlic cv. '*Gujarat*' *Garlic-4* was planted manually keeping the row distance of 15 x 10 cm at 600 kg seed/ha in second week of November during both the years of experimentation. Rice straw mulch was spread after planting of garlic as per treatment. Pre-emergence herbicides were applied before spreading of rice straw mulch while EPoE and PoE were applied after spreading of rice straw mulch as per treatments using knapsack sprayer fitted with flat fan nozzle. Immediately after sowing a light irrigation was given to the crop for uniform germination and next day the pre emergence herbicides were applied. The observations on number of weeds and dry weed biomass were taken from randomly selected four spots by using 0.25 m^2 iron quadrate from net plot area. Weed control efficiency (WCE) was calculated on the basis of standard formula as suggested by Maity and Mukherjee (2011). At the time of harvest, bulb yield was recorded from the net plot area and converted in to hectare. Data on various observations during the experiment period was statistically analysed as per the standard procedure developed by Cochran and Cox (1957).

RESULTS AND DISCUSSION

Effect on weeds

Based on the two years pooled data, the overall dominance of dicot and monocot weeds was 83.1 and 16.9%, respectively in the experimental field. Over all on pooled basis, the major weeds observed in the experimental field were *Eleusine indica* (8.9%), *Asphodelus tenuifolius* (3.0%), *Setaria gluaca* (0.92%) and *Digitaria sanguinalis* (0.92%) in monocot weeds category and *Chenopodium murale* (60.6%), *Chenopodium album* (15.5%) and *Melilotus indica* (5.2%) in dicot weed category.

Pooled data indicated that density of weeds recorded at 40 and 90 DAP and weed dry biomass at harvest was significantly influenced by mulching and weed management practices while dry weight of weeds was found significant only at harvest (**Table 1**). Significantly lower density (5.72 and 4.63/m^2 at 40 and 90 DAP, respectively) was observed under rice straw mulch 5.0 t/ha applied after planting over no mulch on pooled basis. Lower weed dry biomass of weeds was also observed in case of rice straw mulch 5.0 t/ha applied after planting. This result indicates the effectiveness of rice straw mulch on suppression effect on weeds over without mulch. Mulch controls the weeds by smothering seedlings, prevent day light which helps foster germination from reaching weed seeds and prevents airborne seeds from taking hold on the soil surface (Amoroso *et al.* 2009). At all the intervals maximum density and weed dry weight was recorded under without straw mulch treatment.

Table 1. Weed density and weed dry biomass as influenced by different weed management practices (pooled over 2 years)

Treatment	Weed density at 40 DAP (no./m^2)	Weed dry biomass at 40 DAP (g/m^2)	Weed density at 90 DAP (no./m^2)	Weed dry biomass at 90 DAP (g/m^2)	WCE (%) at 90 DAP	Weed dry biomass at harvest (g/m^2)	WCE (%) at harvest
Mulching (M)							
Without straw mulch	9.28(102)	6.53(53.8)	6.30(49.3)	13.4(280)	-	16.5(341)	-
Rice straw mulch 5.0 t/ha	5.72(45.1)	3.94(23.1)	4.63(28.0)	9.24(141)	-	12.8(227)	-
LSD (p=0.05)	0.270	NS	0.159	NS	-	0.596	-
Weed management practice (W)							
Pendimethalin 500 g/ha PE *fb* HW at 60 DAP	8.71(82.5)	7.17(57.5)	4.47(20.9)	6.38(46.3)	92.9	12.7(195)	78.9
Pendimethalin 1000 g/ha PE,	6.01(38.3)	5.07(29.8)	5.95(35.5)	18.5(420)	36.0	18.6(387)	58.1
Oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP	5.67(38.6)	4.39(24.8)	1.73(2.67)	2.44(7.05)	98.9	8.15(74.5)	91.9
Oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP	9.28(88.2)	4.31(18.6)	4.72(22.6)	5.43(29.3)	95.5	11.4(151)	83.6
Pendimethalin 500 g/ha + oxyfluorfen at 120 g/ha PE (tank-mix)	5.97(41.3)	4.25(22.2)	6.84(55.8)	14.8(309)	52.9	15.0(269)	70.9
Pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (tank-mix)	4.27(18.8)	2.53(5.62)	5.86(36.8)	12.0(180)	72.6	10.9(130)	85.9
Hand weeding at 30 & 60 DAP	4.49(20.3)	2.57(5.93)	3.68(14.0)	5.82(35.1)	94.6	11.0(139)	84.9
Weedy check	15.6(258)	11.6(143)	10.5(121)	25.2(656)	-	29.4(923)	-
LSD (p=0.05)	3.25	3.11	4.50	9.07	-	5.88	-
Interaction M x W	Sig.	Sig.	NS	Sig.	-	Sig.	-

Data are subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values

Among the weed management practices, significantly lower density and dry weight of weeds at 40 DAP was recorded under tank mix application of pendimethalin 500 g/ha EPoE + oxyfluorfen 120 g/ ha EPoE as compared to pendimethalin 500 g/ha PE *fb* HW at 60 DAP, oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP and weedy check. At 90 DAP, application of oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP recorded significantly lower density of weeds as compared to tank mix application of pendimethalin 500 g/ha + oxyfluorfen 120 g/ha PE and weedy check. Birgani and Sekhavat (2011) observed that application of oxyfluorfen effectively reduced more dry weight of weeds than other herbicides. The variation in density of weeds under different treatments might be due to effectiveness of herbicides and time of application. These findings are in accordance with the results of Shashidhar *et al*. (2013), they also reported that application of oxyfluorfen and pendimethalin provide effective control of weeds in garlic. At harvest, significantly lower dry weight of weeds was recorded under application of oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP but it was at par with tank mix application of pendimethalin 500 g/ha EPoE + oxyfluorfen 120 g/ha EPoE, twice hand weeding at 30 and 60 DAP, oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP and pendimethalin 500 g/ha PE *fb* HW at 60 DAP. The reduction in density of weed in herbicide treatments might be due to broad spectrum herbicidal effect on control of weeds which ultimately reflected in recording lower dry weight of weeds. These results are agreement with the findings of Sampat *et al*. (2014) and Mohite *et al*. (2015). Based on the two years pooled data, weedy check registered the highest density and dry weight of weeds at 40, 60 DAP and at harvest. The highest weed control efficiency of 91.9 per cent was recorded under application of oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP closely followed by tank mix application of pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE and twice hand weeding at 30 and 60 DAP. Higher weed control efficiency under said treatments might be due to equally effective in lowering total weed biomass as compared to other weed control treatments.

Pooled data on interaction effect presented in Table 3 indicated that dry weight of weeds at harvest was recorded significantly lower under rice straw mulch 5 t/ha along with application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP (M_1W_3) but it was at par with rice straw mulch 5 t/ha along with tank mix application of pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (M_1W_6). The lower weed dry weight under said treatment might be due to suppression effect of mulch on weeds as well as control of weeds with herbicides which ultimately reduced the density of weeds and thereby weed dry weight. Significantly the highest dry weight of weeds was recorded in weedy check under rice straw mulch 5 t/ha and without mulch treatment.

Effect on crop

Plant stand was found to be non significant at 15 DAP while it was significant at harvest due to mulching treatment in pooled results (**Table 2**). Significantly higher plant stand (7.19 no./m^2) was observed under rice straw mulch 5 t/ha applied after

Table 2. Effect of mulching and weed management practices on growth, yield attributes, yield and economics of garlic (pooled over two years)

Treatment	Plant stand (no./m row length)		Plant height (cm)		Plant dry biomass (g/plant at 60 DAP	Bulb weight (g)	Bulb yield (t/ha)			Gross return (x10^3 `/ha)	Cost of cultivation (x10^3 `/ha)	Net return (x10^3 `/ha)	B:C ratio
	At 15 DAP	At harvest	At 60 DAP	At 90 DAP			2016-17	2017-18	Pooled				
Mulch (M)													
Without mulch	9.82	6.07	37.7	54.4	0.78	6.11	2.70	2.81	2.76	82.69	87.98	-5.30	0.92
With mulch (5.0 t/ha)	9.79	7.19	42.4	61.0	1.21	12.2	6.24	6.06	6.15	184.57	94.76	89.81	1.93
LSD (p=0.05)	NS	0.38	1.25	2.57	0.04	0.32	0.39	0.30	0.16	-	-	-	-
Weed management practice (W)													
Pendimethalin 500 g/ha PE *fb* HW at 60 DAP	9.82	7.07	44.2	57.9	1.04	10.5	4.59	4.50	4.55	136.50	92.94	43.56	1.44
Pendimethalin 1000 g/ha PE	9.77	6.42	41.5	61.5	1.12	7.20	2.94	3.23	3.09	92.55	88.42	4.13	1.02
Oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP	9.75	8.35	38.7	59.0	1.19	13.6	7.71	7.17	7.44	223.05	92.85	130.20	2.39
Oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP	9.85	7.42	40.0	54.8	0.94	9.30	4.75	4.51	4.63	138.90	92.85	46.05	1.49
Pendimethalin 500 g/ha PE + oxyfluorfen 120 g/ha PE (tank-mix)	9.82	6.23	41.5	61.2	1.10	9.36	4.30	4.31	4.31	129.30	88.86	40.44	1.42
Pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (tank-mix)	9.88	7.67	38.6	59.2	1.09	10.4	5.57	5.51	5.54	166.35	88.86	77.49	1.84
Hand weeding at 30 and 60 DAP	9.83	7.88	38.2	56.0	1.09	11.3	5.81	6.04	5.92	177.75	100.23	77.52	1.76
Weedy check	9.72	2.00	37.7	52.0	0.39	1.90	0.10	0.21	0.15	4.65	85.99	-81.34	0.05
LSD (p=0.05)	NS	1.59	NS	NS	0.32	0.50	0.46	0.31	0.27	-	-	-	-
Interaction M x W	NS	NS	Sig.	NS	Sig.	Sig.	Sig.	Sig.	Sig.	-	-	-	-

planting as compared to without mulch in pooled results. Similarly, plant height measured at 60 and 90 DAP, plant dry biomass at 60 DAP, bulb weight and bulb yield was recorded significantly higher under rice straw mulch 5 t/ha applied after planting as compared to without mulch in pooled results. Higher yield attributes and yield indicated the positive effect of rice straw mulch on moisture retention, temperature regulation and weed suppression, which invariably become manifested in higher bulb yield of garlic. Increasing yield attributes of garlic due to application of straw mulch was also observed by Jamil *et al*. (2005). Higher bulb yield of garlic in response to mulching have been reported by Umar *et al*. (2000).

Among weed management practices, significantly the lowest plant stand was observed under weedy check at harvest while maximum plant stand was recorded under application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP in pooled results. The lower plant stand under weedy check treatment might be due to sever crop-weed competition suppress the growth of plant and restrict the photosynthesis. These results are in conformity with the results of Jamil *et al*. (2005). Further, plant height at both the intervals was found to be non significant due to different weed management practices. Significant variation was observed in plant dry biomass due to weed management practices at 60 DAP in pooled. Significantly higher plant dry biomass (1.19 g/plant) was recorded with rice straw mulch 5.0 t/ha as compared to weedy check. Garlic bulb weight was recorded significantly the highest under application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP. The intense competition of garlic plants with weeds resulted in a decrease in the weight of produced cloves of garlic. Significantly the highest bulb yield (7.44 t/ha) was obtained under application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP. The higher yield under application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP might be due to plant used the best from the resulted ecological niche under weed free environment resulted in enhanced availability of all the resources to the optimal level and it could transfer more photosynthetic materials to the reproductive organs and it could increase the bulb yield with producing more number of cloves/bulb with higher weight. Present findings are in close agreement with the findings of Makani and Shimi, (2009), Malik *et al*. (2017) and Siddhu *et al*. (2018). Interaction effect on pooled results indicated that significantly the highest bulb weight and bulb yield was recorded under rice straw mulch 5.0 t/ha along with application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP (**Table 4**). While the lowest bulb weight and bulb yield was observed in case of weedy check treatment combination in pooled.

Table 3. Interaction effect of mulching and weed management practices on weed dry biomass (g/m^2) at harvest (pooled over two years)

Weed management practice / Rice straw Mulch	Pendimethalin 500 g/ha PE *fb* HW at 60 DAP	Pendimethalin 1000 g/ha PE	Oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP	Oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP	Pendimethalin 500 g/ha PE + oxyfluorfen 120 g/ha PE (TM)	Pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (TM)	Hand weeding at 30 and 60 DAP	Weedy check
Without mulch	13.4	19.6	9.62	13.0	20.7	13.1	11.6	30.8
With mulch (5.0 t/ha)	12.0	17.5	6.68	9.77	9.23	8.59	10.4	28.1
LSD (p=0.05) 2.18								

Table 4. Interaction effect of mulching and weed management practices on bulb weight and bulb yield (pooled over two years)

Weed management practice / Rice straw mulch	Pendimethalin 500 g/ha PE *fb* HW at 60 DAP		Pendimethalin 1000 g/ha PE		Oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP		Oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP		Pendimethalin 500 g/ha PE + oxyfluorfen 120 g/ha PE (TM)		Pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (TM)		Hand weeding at 30 and 60 DAP		Weedy check	
	bulb weight (g)	bulb yield (t/ha)	bulb weight (g)	bulb yield (t/ha)	bulb weight (g)	bulb yield (t/ha)	bulb weight (g)	bulb yield (t/ha)	bulb weight (g)	bulb yield (t/ha)	bulb weight (g)	bulb yield (t/ha)	bulb weight (g)	bulb yield (t/ha)	bulb weight (g)	bulb yield (t/ha)
Without mulch	6.29	2.31	3.83	1.11	9.89	6.04	8.05	3.81	4.65	1.08	6.70	3.18	8.13	4.42	1.35	0.10
With mulch (5.0 t/ha)	14.7	6.79	10.6	5.06	17.3	8.83	10.6	5.45	14.1	7.54	14.0	7.91	14.4	7.43	1.73	0.21
	bulb weight (g)	bulb yield (t/ha)														
LSD (p=0.05)	0.97	0.44														

Economics

Two years pooled data presented in **Table 2** further indicated that rice straw mulch 5.0 t/ha recorded higher gross return, net return and benefit cost ratio as compared to without mulch. Among weed management practices, application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP recorded higher gross return, net return and benefit cost ratio which was closely followed by tank mix application of pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE and twice hand weeding carried out at 30 and 60 DAP.

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