Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 2140-2144
Received: 13-07-2020
Accepted: 17-08-2020

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Planting pattern and weed management practices on the productivity of onion (*Allium cepa* L.)

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Abstract
Weed infestation is one of the main yield limiting factors for onion. The yield as well as nutrient uptake by crop is reduced substantially on account of increased crop weed competition on a high cost input oriented agriculture system. Weed consumes the costly input and thrives to reduce the yield value and profit of the crop if allow to grow. Continuous and imbalanced use of herbicides adversely affects the sustainability of agricultural production besides causing environmental pollution. There is need to develop most effective and economical weed control and planting pattern for obtaining higher yield of onion as well as profitability in its production. With this, the investigation entitled "Planting pattern and weed management practices on the productivity of onion (*Allium cepa* L.)" was undertaken during *rabi* 2013-14 and 2014-15 at Student's Instructional Farm of C.S.A.U.A.T, Kanpur, UP, India to assess the impact of planting pattern and weed control treatments on weed growth and performance of onion. Twenty combination treatments of four planting patterns (Flat bed without rice straw, Flat bed with rice straw, Raised bed with rice straw and Raised bed without rice straw) with five weed management practices [Control (Weedy check), Pendimethalin @ 1 kg/ha, Oxyfluorfen @ 0.250 kg/ha, Pendimethalin @ 0.750 kg/ha + HW and Oxyfluorfen @ 0.225 kg/ha + HW] was laid out in FRBD replicated thrice. Among the weed management practices, the treatments of oxyfluorfen or pendimethalin along with one hand weeding were found most effective in controlling weeds as well as on yield and yield attributes. Integration of raised bed with 1 t/ha rice straw planting pattern and oxyfluorfen @ 225 g a.i./ha + one hand weeding 40 DAT of onion weed control method manages weed most effectively producing highest bulb yield (211.05 q/ha) and found to be the most economical in onion cultivation and may be recommended for higher productivity of *rabi* onion in central Uttar Pradesh condition.

Keywords: Onion, Oxyfluorfen, Pendimethalin, Planting pattern, Productivity and Weed control.

Introduction
Onion (*Allium cepa* L.), family Amaryllidaceae is one of the most important commercial vegetable crops cultivated extensively in India. It is an indispensable item in every kitchen as condiment and vegetable, therefore commands an extensive internal market. Recent research has suggested that onion in the diet may play vital role in preventing coronary heart diseases and other aliments (Sangha and Bering, 2003) [9]. In India, onion is being grown in an area of 0.76 million hectares with production of 12.17 million tons and the productivity is 16.03 t/ha which is low. In Karnataka, onion is cultivated in an area of 1.41 lakh hectares with production of 22.66 lakh tonnes and the average productivity is 16.04 t/ha (http://nhb.gov.in/ online) which is low compared to world average.

Among the multiple constraints for low productivity in onion, poor weed management practices, imbalanced nutrition and water are the main limiting factors. Onion is a shallow rooted crop. Weeds interfere with the development of onion bulb by competing for moisture, nutrient, light and space and thereby reduce bulb yield to the extent of 40-80 % (Verma and Singh, 1996 and Tewari *et al.*, 2003) [10, 11]. Owing to inherent characteristics of onion such as, short stature, non-branching habit, sparse foliage, shallow root system and extremely slow growth in initial stages, weeds offer severe competition throughout the crop growth. Any root pruning by cultivation reduces bulb growth. The conventional method of weed control *i.e.*, hand weeding is labour intensive, time consuming, cumbersome and under many situations uneconomical. Chemical weed control is a better supplement to conventional methods and forms an integral part of the modern crop production. Thus, use of herbicide is one of the alternatives left with the farmers to eliminate crop weed-competition at early growth stage of crop. Pendimethalin, oxyflourfen and fluchloralin are few selective herbicides recommended for controlling weeds in onion. The investigation entitled "Planting pattern and weed management practices on the productivity of onion (*Allium cepa* L.)" has therefore, planned to find out the suitable land configuration and effective weed control method for onion.

Materials and Methods

The experiment was carried out during *rabi* 2013-14 and 2014-15 at Student's Instructional Farm of C.S. Azad University of Agriculture and Technology, Kanpur, UP, India. The soil was sandy loam in texture, pH slightly alkaline (8.20), low in organic carbon (0.41 %) and available nitrogen (254 kg/ha), medium in available phosphorus (19 kg/ha) and available potassium (181 kg/ha). Four planting patterns with five weed management practices were designed in factorial randomized block design (FRBD) replicated thrice. The planting patterns and the weed management practices are presented in Table 1. Onion seed, N-53 (Nifed) was sown in nursery bed. Seedlings were treated with Azotobactor (100 %) @ 1 kg/ha and PSB @ 2 kg/ha. Healthy bulblets uniform in shape and size were selected and sixty days old seedlings were transplanted with inter and intra row spacing of 15 cm and 10 cm, respectively at a shallow depth. A uniform dose of 125-50-125 kg N-P-K/ha + 10 tons FYM/ha was applied in the whole experimental area during land preparation. The herbicidal treatments, Oxyflourfen (Goal 23.5 % EC) @ 0.250 a.i. kg/ha and Pendimethalin (Stomp 30 % EC) @ 1.0 a.i. kg/ha was applied as pre-emergence (3 DAT). Rice straw was mulched between onion rows at 15 DAT in respective treatment plots @ 1 t/ha. Manual weeding was done at 40 DAT according to the treatment.

To see the impact of different treatments on weeds and crop, a number of observations on growth and yield attributes of crop and weed ecology were recorded at different stages of crop growth. Species-wise number of weeds was recorded from each plot at 30, 60 DAT and at harvest stages. These weed densities were again weighed for their dry weight. The weed control efficiency (WCE) and weed index (WI) of different weed management practices were calculated. The bulb diameter at 30, 60 DAT and at harvest stages and yield were also observed. The bulb yield per hectare was recorded on the basis of yield obtained from each plot. The detailed net production value for various treatments was also worked out. The data recorded for various characters of crop and weeds were subjected to statistical analysis of variance technique for FRBD. Overall differences were tested by 'F' test at 5 % level of significance as suggested by Cochran and Cox, 1959 [4]. In case of weed population, the data were subjected to square root transformations with the formula $\sqrt{x+0.5}$ before analysis.

Table 1: Treatment details of planting pattern and weed management practices of onion

Notations	Treatment details
Planting pattern	
M_1	Flat bed without rice straw
M_2	Flat bed with rice straw
M_3	Raised bed with rice straw
M_4	Raised bed without rice straw
Weed management practices	
W_1	Control (Weedy check)
W_2	Pendimethalin @ 1 kg/ha
W_3	Oxyfluorfen @ 0.250kg/ha
W_4	Pendimethalin @ 0.750 kg/ha + HW
W_5	Oxyfluorfen@ 0.225kg/ha + HW

Results and Discussion

Weed density and biomass

The predominant weed species infesting were grassy weeds, viz. *Sorghum halepense* (L.) pers., *Phalaris minor* Ritz., *Cynodon dactylon* (L.) pers.; broad leaf weed *Chenopodium album* L. and sedge weed *Cyperus rotundus* L. during the two experimental years. The other weeds infesting the experimental field were *Anagallis arvensis* L., *Melilotus indica* (L.) *Parthenium hysterophorus* I., *Poa annua* L., *Asphodelus tenuifolius* Cavan., *Amaranthus spp.*, *Portulaca oleracea* L., *Phyllanlthus niruri* Hook.f., *Ageratum conyzoides* L., *Medicago denticulate* L. and *Solanum nigrum* L. during both the years. With different planting patterns, the total weeds emerged out and survived were significantly lesser in M_3 and M_4 compared to M_1 or M_2 at 30, 60 DAT and at harvest (Table 2). At 30 DAT, the total weeds emerged out and survived were significantly lesser in M_3 and M_4 compared to M_2 or M_1. At 60 DAT, when maximum population of total weeds was recorded, the treatments *i.e.*, M_3, M_4 and M_2 significantly reduced the total weed population compared to M_1 by the margins of 31.4, 18.7 and 15.8 %, respectively on mean basis of both year data. Weed management practices also influenced total weed population significantly in all cases of study. All herbicidal treatments reduced total weed population significantly of larger margins compared to W_1 in all observations. Among herbicides, oxyfluorfen was found significantly more effective than pendimethalin in reducing total weed population. The treatments of herbicide + hand weeding further reduced the weed population compared to herbicide alone application. At maximum weed stage of 60 DAT, the weed control treatments W_5, W_4, W_3 and W_2 caused 80.2, 72.7, 59.8 and 54.5 % total weed population reduction, respectively, in mean data as compared to W_1 treatment. As expected, dry matter production of total weed population was also influenced significantly by both the treatment factors under the study (Table 2). The treatment, M_3 produced significantly the lowest weed dry matter while the highest weed dry matter was produced in M_1 at the stages of 30, 60 DAT and at onion harvest stages. All weed control treatments reduced the production of weeds dry matter significantly compared to weedy check control treatment in all observations. The treatment, W_5 produced significantly the lowest weeds dry matter compared with the treatment W_1 at the stage of 30, 60 DAT and at harvest of onion. The interaction effect of planting pattern and weed management practices was found insignificant in any observation on weed density and dry matter production of weeds. In general, weed density of all type of weeds was recorded maximum at 60 DAT of onion followed by 30 DAT and minimum at crop harvest. It might be due to the reason that beneficial effect of land preparation and pre-emergence applied herbicides on weed control diluted with the passing of time, thus weeds sharing moisture and nutrients with crop growth and increased their density till later crop stage while at harvest stage, some of the weeds completed their life, the total weed density reduced. Dry weight of weeds decreased with the increase in weed-free period, but increased with the increase in weedy period. The combinations of hand weeding along with the application of pendimethalin @ 1.0 kg/ha pre-plant incorporation (PPI) and oxyfluorfen @ 0.250 kg/ha post-emergence (POE) was found better. However, weed management with three hand weedings (HW) at 20, 40 and 60 DAT recorded significantly the lowest weed density, dry weight of weeds and higher WCE and recorded maximum growth and yield attributes of onion *viz.* plant height, neck thickness, bulb weight, bulb diameter and bulb yield (Kalhapure and Shete, 2013) [5].

Table 2: Effect of planting pattern and weed management practices on weed density (per m^2) and weed dry weight (g/m^2) at 30 and 60 DAT and at harvest stage of onion

Treatments	No. of weeds/m^2									Weed dry weight (g/m^2)								
	30 DAT			60 DAT			Harvest			30 DAT			60 DAT			Harvest		
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
Planting pattern																		
M_1	6.03 (39.00)	6.74 (48.78)	6.38 (43.89)	6.60 (46.80)	7.37 (58.54)	6.98 (52.67)	5.41 (31.20)	6.03 (39.02)	5.72 (35.11)	3.62 (13.65)	4.03 (17.07)	3.82 (15.36)	5.91 (37.44)	6.60 (46.83)	6.25 (42.14)	5.27 (29.64)	5.88 (37.07)	5.57 (33.36)
M_2	5.53 (32.84)	6.18 (41.05)	5.85 (36.96)	6.05 (39.41)	6.76 (49.30)	6.40 (44.36)	4.96 (26.27)	5.54 (32.86)	5.25 (29.57)	3.33 (11.49)	3.70 (14.38)	3.51 (12.94)	5.42 (31.53)	6.06 (39.44)	5.74 (35.49)	4.84 (24.96)	5.40 (31.22)	5.12 (28.09)
M_3	5.02 (26.74)	5.60 (33.44)	5.31 (30.09)	5.49 (32.09)	6.13 (40.13)	5.81 (36.11)	4.51 (21.39)	5.02 (26.75)	4.76 (24.07)	3.03 (9.36)	3.37 (11.70)	3.2 (10.53)	4.92 (25.67)	5.49 (32.10)	5.20 (28.89)	4.39 (20.32)	4.90 (25.41)	4.64 (22.87)
M_4	5.45 (31.72)	6.08 (39.64)	5.76 (35.68)	5.96 (38.06)	6.66 (47.57)	6.31 (42.82)	4.89 (25.38)	5.45 (31.71)	5.17 (28.55)	3.28 (11.10)	3.65 (13.87)	3.46 (12.49)	5.34 (30.45)	5.96 (38.05)	5.65 (34.25)	4.76 (24.11)	5.32 (30.13)	5.04 (27.12)
S.Em. (±)	0.09	0.10	0.09	0.10	0.11	0.10	0.08	0.09	0.08	0.05	0.06	0.05	0.09	0.10	0.09	0.08	0.08	0.08
C.D. (p=0.05)	0.26	0.28	0.27	0.29	0.32	0.30	0.22	0.26	0.24	0.15	0.16	0.15	0.24	0.28	0.26	0.22	0.24	0.23
Weed management practices																		
W_1	8.36 (69.98)	9.35 (87.50)	8.85 (78.74)	9.15 (83.97)	10.23 (105.00)	9.69 (94.49)	7.49 (55.98)	8.36 (70.00)	7.92 (62.99)	4.98 (24.49)	5.56 (30.63)	5.27 (27.56)	8.20 (67.18)	9.16 (84.00)	8.68 (75.59)	7.30 (53.18)	8.16 (66.50)	7.73 (59.84)
W_2	5.67 (69.98)	6.33 (87.50)	6.0 (35.84)	6.21 (38.25)	6.93 (47.76)	6.57 (43.01)	5.08 (25.50)	5.67 (31.84)	5.37 (28.67)	3.41 (11.16)	3.79 (13.93)	3.6 (12.55)	5.56 (30.60)	6.20 (38.21)	5.88 (34.41)	4.96 (24.23)	5.53 (30.25)	5.24 (27.24)
W_3	5.33 (28.15)	5.95 (35.18)	5.64 (31.67)	5.83 (33.78)	6.51 (42.21)	6.17 (38.00)	4.78 (22.52)	5.33 (28.14)	5.05 (25.33)	3.21 (9.85)	3.57 (12.31)	3.6 (11.08)	5.23 (27.02)	5.83 (33.77)	5.53 (30.40)	4.66 (21.39)	5.20 (26.73)	4.93 (24.06)
W_4	4.41 (19.05)	4.93 (23.90)	4.61 (21.48)	4.82 (22.86)	5.39 (28.68)	5.10 (25.77)	3.96 (15.24)	4.42 (19.12)	4.19 (17.18)	2.67 (6.67)	2.97 (8.37)	3.39 (7.52)	4.32 (18.29)	4.83 (22.94)	4.57 (20.62)	3.86 (14.48)	4.31 (18.16)	4.08 (16.32)
W_5	3.77 (13.83)	4.20 (17.30)	3.98 (15.57)	4.12 (16.59)	4.59 (20.76)	4.35 (18.68)	3.39 (11.06)	3.77 (13.84)	3.58 (12.45)	2.30 (4.84)	2.55 (6.06)	2.82 (5.45)	3.70 (13.27)	4.12 (16.1)	3.91 (14.72)	3.31 (10.51)	3.68 (13.15)	3.49 (11.83)
S.Em. (±)	0.10	0.11	0.10	0.11	0.13	0.12	0.09	0.10	0.09	0.06	0.06	0.06	0.10	0.11	0.10	0.08	0.09	0.08
C.D. (p=0.05)	0.29	0.32	0.30	0.32	0.36	0.34	0.25	0.29	0.27	0.16	0.18	0.17	0.27	0.31	0.29	0.24	0.27	0.25

Values are square root $\sqrt{x+0.5}$ transformed and original values are given in parenthesis.

Weed control efficiency and weed index

Planting pattern and weed control treatments influenced weed control efficiency (WCE) and weed Index (WI) in onion during both the years (Fig. 1). Among planting pattern, M_3 recorded highest WCE followed by treatment of M_4. M_2 also showed higher WCE. It proved that raised bed system of onion planting is more effective than flat bed system in controlling weeds. Similarly, rice straw mulch also showed its effectiveness in controlling weeds of onion compared to no rice straw irrespective of planting systems of onion. In case of weed control treatments, W_5 was found most efficient in controlling onion weeds by achieving higher WCE followed by treatment W_4. Alone application of herbicides were found comparatively less effective with WCE in W_3 and W_2 treatments. Among the treatments with difference in planting pattern, suppression effect of weed on crop plant was observed through WI. M_3 had highest yield so in comparison with it, the highest WI was found in M_1 followed by M_2 and M_4. Impact of weed management practices on WI was observed least with highest WI among the treatments in Control (Weedy check) followed by W_2. Weed management practice of hand weeding twice at 20 and 40 DAT significantly reduced the density and dry weight of weeds, resulting in improved WCE, elevated stature of yield attributes and higher bulb yield and it was comparable to other weed management practice (Chandrika *et al.*, 2009) [2]. Application of new formulation of oxyfluorfen (23.5 % EC) at 200 g/ha as pre-emergence herbicide can keep the weed density and dry weight below the economic threshold level and increase the bulb weight and yield in onion. However, oxyfluorfen @ 400 g/ha gave significantly lower weed density, weed dry weight and higher WCE in onion field (Ramalingam *et al.*, 2013) [6]. Effective weed control was under oxyfluorfen 0.26 kg a.i./ha with hand weeding (30 DAT) recorded higher WCE (97.11 %) which was next to weed free check at all stages of crop growth (Sable *et al.*, 2013) [8]. Among weed management practices, oxyfluorfen was found more effective than pendimethalin in reducing weed population. Effectiveness of both the herbicides increased when supplemented with one hand weeding at 40 DAT crop. Both herbicides were applied as pre-emergence thus controlled weeds efficiently in earlier stage and hand weeding at 40 DAT further removed the weeds, thus weed density reduced to minimum under integration of herbicide and hand weeding. Superiority of oxyfluorfen over pendimethalin in controlling weeds has also been reported by Chopra and Chopra (2007) [3].

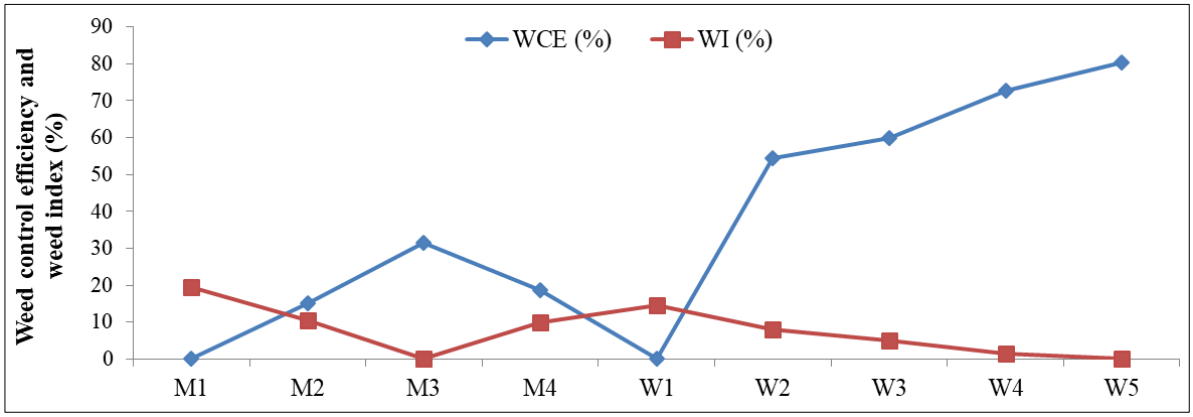

Fig 1: Effect of planting pattern and weed practices on weed control efficiency (%) and weed index (%) in onion field

Yield

In general, bulb diameter increased with age of plant till harvest, however the rate of increase was found higher between 60 DAT and harvest, irrespective of treatments (Table 3). The effect of both the factors was found significant on bulb diameter during both the years. At final stage of harvest, M_3 recorded the highest diameter and was found to be 6.0, 7.1 and 11.5 % higher than bulb diameter measured in M_4, M_1 and M_2 treatments, respectively in mean data of both the experimental years. The weed control treatments increased bulb diameter significantly over W_1 in all observations except at 60 DAT when W_2 could not show significant increase over W_1 during both study year. At highest bulb diameter stage of crop harvest, treatments W_2, W_3, W_4 and W_5 could increase bulb diameter over W_1 by the margins of 10.0, 13.3, 16.7 and 18.8 %, respectively on the basis of mean over the years. In case of planting patterns, raised bed produced significantly higher bulb yield than flat bed system and the rice straw mulch also produced significantly higher bulb yield than no rice straw during both the years (Table 3). Thus, treatment M_3 produced significantly the highest bulb yield while the lowest bulb yield was produced under treatment M_1. All weed control treatments gave significantly higher bulb yield than W_1 during both the years. Among weed control treatments, W_5 being at par with W_4 and W_3 produced significantly higher bulb yield than W_2 treatment. Weeds caused bulb yield loss from 7.5 to 17.1 % as with different treatments of weed control. From yield point of view, the integrated use of herbicide + hand weeding proved better than herbicide alone. Among herbicides, oxyfluorfen was found higher yield than pendimethalin.

Table 3: Effect of planting pattern and weed management practices on bulb diameter (cm) of onion at successive crop growth periods and bulb yield (q/ha) of onion at harvest

Treatments	Bulb diameter (cm)									Bulb yield (q/ha)		
	30 DAT			60 DAT			Harvest					
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
Planting pattern												
M_1	1.91	1.72	1.82	4.24	3.81	4.03	4.83	4.35	4.59	168.52	151.67	160.10
M_2	1.99	1.79	1.89	4.41	3.97	4.19	5.03	4.53	4.78	187.24	168.52	177.88
M_3	2.09	1.88	1.99	4.63	4.17	4.40	5.28	4.75	5.12	209.14	188.22	198.68
M_4	2.01	1.81	1.91	4.45	4.01	4.23	5.08	4.57	4.83	188.34	169.51	178.92
S.Em. ±	0.04	0.03	0.03	0.08	0.07	0.07	0.10	0.09	0.09	3.51	2.97	3.24
C.D. (p=0.05)	0.11	0.09	0.5	0.23	0.21	0.22	0.27	0.27	0.27	10.06	8.51	3.28
Weed management practices												
W_1	1.81	1.62	1.72	3.93	3.53	3.73	4.53	4.07	4.30	170.83	153.75	162.29
W_2	1.92	1.73	1.83	4.32	3.89	4.11	4.97	4.48	4.73	183.66	165.30	174.48
W_3	2.01	1.81	1.91	4.52	4.07	4.30	5.13	4.61	4.87	189.97	170.97	180.47
W_4	2.11	1.90	2.01	4.67	4.20	4.44	5.28	4.75	5.02	197.09	177.38	187.24
W_5	2.16	1.94	2.05	4.73	4.25	4.498	5.38	4.84	5.11	199.99	179.99	189.99
S.Em. ±	0.04	0.04	0.04	0.09	0.08	0.08	0.11	0.11	0.40	3.93	3.33	3.63
C.D. (p=0.05)	0.13	0.11	0.12	0.26	0.24	0.25	0.31	0.30	0.30	11.24	9.52	10.38

The effect of planting pattern and weed management interaction was found significant on bulb yield; therefore, the yield was maximized under combination of both the treatment factors at their best levels (Table 4). The treatment combination of oxyfluorfen @ 0.225 kg/ha + hand weeding in raised bed system with rice straw mulch produced highest bulb yield of onion during two different years of experiment. These yields were found to be 45.0 % higher than the lowest bulb yield obtained under Weedy check and Flat bed with rice straw treatment combination during the years of study. Integration of oxyfluorfen 0.15 kg a.i./ha, oxadiargyl @ 0.1 kg a.i./ha or pendimethalin @1.0 kg a.i./ha with one hand weeding at 45 DAT proved to be effective in significantly reducing weed density and increasing the bulb yield over application of respective herbicides alone. Among the herbicides oxyfluorfen @ 0.15 kg a.i./ha with one hand weeding at 45 DAT recorded highest bulb yield and was on par with oxadiargyl @ 0.1 kg a.i./ha and pendimethalin @1.0 a.i./ha with one hand weeding at 45 DAT. Hand weeding at 30, 45 and 60 DAT has recorded highest WCE of 80-88 %, improved the plant height, number of leaves per plant, bulb diameter, bulb weight and yield per hectare and proved significantly superior over herbicide alone or integrated weed management treatments (Bharathi *et al.*, 2011) [1].

Table 4: Combined effect of planting patterns and weed management practices on bulb yield (q/ha) of onion

Weed control practices	2013-14				2014-15			
	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4
W_1	153.20	170.20	189.42	170.50	137.88	153.18	170.48	153.45
W_2	164.25	182.50	204.10	183.80	147.83	164.25	183.69	165.42
W_3	169.92	188.80	211.06	190.10	152.93	169.92	189.95	171.09
W_4	176.31	195.90	218.95	197.20	158.68	176.31	197.06	177.48
W_5	178.92	198.80	222.15	200.10	161.03	178.92	199.94	180.09
S.Em. (±)	7.85	-	-	-	6.65	-	-	-
C.D. (p=0.05)	NS	-	-	-	NS	-	-	-

Net production value

Lower the cost and higher the benefit, better the B:C ratio (Table 5). Planting pattern of M_3 required maximum cultivation cost which was found 1.22, 1.96 and 3.22 % higher than the cultivation cost of other treatment. Among weed management practices, W_5 required maximum cost and it was found 0.58, 6.10, 6.69 and 7.94 % higher than the cultivation cost of remaining treatments. These results show that cost of onion cultivation was more influenced by weed management practices than by planting patterns. Similarly,

the mean data of 2-years show that planting pattern of M_3 recorded highest with 11.0, 11.7 and 24.1 % higher than the gross income obtained from M_4, M_1 and M_2 patterns, respectively. It shows that M_2 gave almost similar return to M_4. In case of weed management, the practice of W_5 recorded highest gain return and it was found Rs. 2876, 10945, 18113 and 32663/ha higher than the gross return obtained under practices of W_4, W_3, W_2 and W_1, respectively, on mean basis of 2-year results. These data also show that different weed management practices increased gross return remarkably over W_1 by the margins from 7.52 % to 16.9 %, respectively. All weed control practices increased net return remarkably over W_1 by the margins from 9.7 to 20.2 % on mean basis of 2-year data. Net return was also found to be more influenced by planting patterns than weed management. The benefit: cost ratio was recorded highest of 3.55 under pattern of M_3 followed by M_4 with 3.19 ratio against lowest of 2.79 ratio under M_1 in mean data of 2-years study. Among weed management practices, W_3 recorded highest B:C ratio but is was found considerably higher only over W_1. The practices W_2, W_4 and W_5 recorded B:C ratio which were nearer to W_3 but considerably higher over W_1. The highest net return (Rs. 83278/ha) was obtained with pendimethalin (1.5 kg/ha) sprayed at 48 hrs after transplanting + hand weeding at 60 DAT. Alachlor at 1.5 kg/ha resulted in the lowest weed control cost (Rs. 1277) and the highest marginal benefit:cost ratio (3.95) (Rameshwar *et al.*, 2002) [7].

Among weed management practices, the treatments of oxyfluorfen or pendimethalin along with one hand weeding were found most effective in weed parameter point of view as well based on yield and yield attributes. Consequently, better performance of these treatments in term of bulb yield could be attributed to better expression of their yield attributes due to reduction in crop weed competition. Furthermore, 'raised bed with straw' among planting patterns and oxyfluorfen + one and weeding method of weed control were found most economical in onion cultivation.

Table 5: Effect of planting pattern and weed management practices on net production value

Treatments	Net production value											
	Total cost of cultivation			Gross return			Net return			B:C ratio		
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
Planting pattern												
M_1	49167	51689	50428	185372	197168	191270	136205	145479	140842	2.77	2.81	2.79
M_2	50167	52689	51428	205956	219071	212514	155797	166332	161090	3.10	3.15	3.13
M_3	50779	53329	52054	230050	244686	237368	179270	191349	185310	3.52	3.58	3.55
M_4	49779	52329	51054	207174	220345	213760	157395	168016	162706	3.18	3.20	3.19
Weed management practices												
W_1	48237	50651	49444	187913	199882	193898	139676	149221	144449	2.89	2.94	2.92
W_2	48790	51261	50026	202029	214867	208448	153239	163606	158423	3.13	3.18	3.16
W_3	49040	51561	50301	208967	222264	215616	159927	170703	165315	3.26	3.30	3.28
W_4	51750	54380	53065	216789	230581	223685	165049	196201	170625	3.18	3.24	3.21
W_5	52050	54692	53371	219992	233129	226561	167942	179301	173622	3.22	3.27	3.25

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