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Research Communication

Effect of tillage and weed management on weed biomass and productivity of summer maize (*Zea mays*)

D.P. MODAK[1], B. BEHERA[2], S.N. JENA[3], P.K. ROUL[4] AND STUTI DEBAPRIYA BEHERA[5]

Odisha University of Agriculture and Technology, Bhubaneswar, Orissa 751 003

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ABSTRACT

A field experiment was conducted during the summer season of 2014 at Bhubaneswar, Odisha to study the effect of tillage and weed management on weed biomass and productivity of summer maize (*Zea mays* L.). The experiment comprised of 3 tillage methods, viz. conventional tillage, minimum tillage and zero tillage, and 6 different types of weed management practices, viz. atrazine 1.25 kg/ha pre-emergence, 2,4-D 0.5 kg/ha (post-emergence), atrazine 1.25 kg/ha (pre-emergence) + 2,4-D 0.5 kg/ha (post-emergence), atrazine @1.25 kg/ha (pre-emergence) + 1 hand-weeding 30 days after planting (DAP), hoeing and weeding at 15 and 30 DAP and weedy check, and was laid out in split-plot design with 3 replications. The 3 tillage methods were allocated to main plots and 6 weed management practices to subplots. 'Nilesh' was taken as test variety of maize. At harvesting, zero tillage recorded the minimum weed biomass and both minimum and conventional tillage exhibited significantly higher weed biomass than zero tillage. Among the weed-management practices, atrazine + 1 hand-weeding resulted in the minimum weed biomass at 15 DAP and harvesting, with the maximum weed-control efficiency of 84% at harvesting. The interaction effects of tillage and weed-management practices on yield of grain and stover were found significant. Atrazine + 1 hand-weeding under zero tillage proved the best with the maximum grain yield of 8.08 t/ha, stover yield of 10.10 t/ha, net return of 88.4 × 10^3₹/ha.

Key words: Correlation, Economics, Maize, Weedflora, Yield attributes, Yield

The conventional system with annual ploughing, carried out at the same depth and with repeated treatments for seedbed preparation with disk-harrows, has several negative impact on physico-chemical and biological characteristics of soil. Conservation tillage is the need of the day. It is a tillage sequence that reduces soil or water loss relative to conventional tillage. It includes both minimum tillage and zero tillage. The adoption of conservation tillage for maize production is increasing, because it reduces time, fuel and labour requirement. There is a need for adoption of the conservation agriculture in India for harnessing crop production profitability (Yadav *et al*., 2016). Heavy weed infestation is a major constraint in maize cultivation. The problem of weed in maize can be mitigated by finding out the best weed-management practice out of various options, viz. application of pre-emergence herbicide alone, post-emergence herbicide alone, herbicide combination, non-chemical methods or integration of chemical and non-chemical methods to ensure weed-free conditions for the crop. Greater growth and yield of maize has been reported in zero till method with use of herbicides (Chopra and Angiras, 2008). Hence, the present experiment was designed to find out the best tillage and weed management for summer maize in rice–maize cropping system under red and lateritic soils of Odisha.

A field experiment, comprising 3 main plots and 6 subplots, was conducted during the summer season of 2014 at Central Research Station, Odisha University of Agriculture and Technology, Bhubaneswar in split-plot design with 3 replications. The 3 main plot treatments comprised conventional tillage (CT), minimum tillage (MT) and zero tillage (ZT). The 6 sub-plot treatments were: pre-emergence application of atrazine @ 1.25 kg/ha (W_1), post-emergence application of 2, 4-D @ 0.5 kg/ha at 30 DAP (W_2), atrazine @ 1.25 kg/ha + 2, 4-D @ 0.5 kg/ha at 30 DAP (W_3), atrazine @ 1.25 kg/ha + 1 hand-weeding at 30 DAP (W_4), hoeing and weeding at 15 and 30 DAP (W_5) and weedy check (W_6). 'Nilesh' hybrid maize was taken as

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[2]Corresponding author's Email: bdbehera1@rediffmail.com

[1]Research Scholar, [2]Professor and Head (Agronomy), [3]Professor (Agronomy), [5]Ph.D. Scholar (Agronomy), [4]Dean, Extension Education

test crop. The soil of the experimental site was sandy loam, with *p*H 6.04, high in organic carbon (0.75%), medium in available nitrogen (287.5 kg/ha) and high in available phosphorus (40.57 kg/ha) and available potassium (289.5 kg/ha). The crop was planted on 21 January in zero-tilled plots and 5 February in minimum and conventionally tilled plots after harvesting of rice grown under medium-land condition. The entire area under conventionally tilled plots were subjected to both primary tillage (ploughing) and secondary tillage before planting seeds. In minimum tilled plots, entire area was subjected to primary tillage, but secondary tillage was given to crop row zone only before planting. In zero tilled plots, planting was done by opening narrow furrows by pointed tip of trench hoe. Nitrogen, phosphorus and potassium were applied @ 120, 26.2 and 50 kg/ha in the form of urea, single superphosphate and muriate of potash, respectively. Full dose of P and K and 25% of N (30 kg/ha) were applied basal to maize. The rest of N was top-dressed in 2 splits–50% N (60 kg/ha) at 20 DAP and the remaining 25% N (30 kg/ha) at tasseling stage. The crop was harvested on 5 May in zero-tilled plots and 15 May in minimum and conventionally tilled plots. Weed-control efficiency was calculated on dry-weight basis at harvesting as per Mani *et al.* (1976).

$WCE(\%) = \frac{X-Y}{X} \times 100$, where X refers to dry weight of weed in weedy check and Y refers to dry weight of weed in treated plot

Twenty-four species of weeds associated with the crop which included 8 grasses, viz. *Acrachne verticillata* (Roxb.) Lindl. Ex Chiov.; syn. *A. racemosa* (Heyne ex Roem. & Schult) Ohwi, *Cynodon dactylon* (L.) Pers., *Dactyloctenium aegyptium* (L.) Willd., *Digitaria ciliaris (*Retz.*) Koeler, Digitaria sanguinalis* (L.) Scop., *Echinochloa colona* (L.) Link., *Eleusine indica* (L.) Gaertn. and *Sporobolus diander* (Retz.) P. Beauv.; 2 sedges, viz. *Cyperus iria* L. and *Cyperus rotundus* L. and 14 broad-leaf weeds, viz. *Acalypha indica* L., *Ageratum conyzoides* L., *Alternanthera philoxeroides* (Mart.) Griseb., *Amaranthus spinosus* L., *Borreria articularis* (L. f) Willd., *Commelina benghalensis* L., *Cynotis cucullata* Kunth., *Eclipta alba* Hassak., *Heliotropium indicum* L., *Oldenlandia corymbosa*, *Physalis minima* L., *Spilanthes acmella, Trianthema portulacastrum* L. and *Tridax procumbens* L.

At 15 DAP, zero tillage resulted in the minimum weed biomass (Table 1). The minimum tillage showed the statistically similar weed biomass and the conventional tillage recorded significantly higher biomass than zero tillage. Among the weed-management practices, all atrazine-based weed-management practices, viz. atrazine alone, atrazine + 2, 4-D and atrazine + 1 hand-weeding recorded significantly less weed biomass than weedy check and hoeing and weeding twice. Chopra and Angiras (2008) reported similar efficacy of atrazine 1.5 kg/ha in *kharif* maize. At harvesting, zero tillage showed the minimum weed biomass and both minimum and conventional tillage

Table 1. Effect of tillage and weed-management on biomass of weeds, weed-control efficiency (WCE) and yield attributes of maize

Treatment	Weed biomass (g/m^2),		WCE	Yield attributes				
	15 DAP	Harvesting	(%) at harvesting	Cob length (cm)	Cob girth (cm)	Grain rows/ cob	Grains/ row	1,000-grains weight (g)
Tillage								
CT, Conventional tillage	2.08* (3.71)**	5.73 (35.40)	–	16.3	13.2	15.9	31.6	241
MT, Minimum tillage	1.95 (3.11)	5.41 (31.57)	–	17.5	13.7	16.2	33.6	249
ZT, Zero Tillage	1.82 (2.53)	4.89 (25.24)	–	18.4	14.3	16.5	35.4	258
SEm±	0.04	0.07	–	0.4	0.2	0.1	0.7	2
CD (P=0.05)	0.15	0.26	–	1.5	0.8	0.4	2.6	8
Weed management								
W_1, Atrazine @1.25 kg/ha	1.48 (1.20)	5.68 (31.38)	60	18.0	13.5	15.8	35.0	252
W_2, 2,4-D@ 0.5 kg/ha	2.56 (5.62)	5.31 (27.36)	65	15.3	12.8	15.4	29.6	222
W_3, $W_1 + W_2$	1.45 (1.10)	4.32 (17.72)	78	19.2	14.7	17.4	37.3	274
W_4, Atrazine @1.25 kg/ha + hand-weeding at 30 DAP	1.39 (0.93)	3.71 (12.86)	84	19.7	15.1	17.9	38.5	277
W_5, Hoeing and weeding twice at 15 and 30 DAP	2.11 (3.45)	4.14 (16.21)	79	18.6	13.9	16.9	36.6	262
W_6, Weedy check	2.71 (6.38)	8.89 (78.90)	0	13.6	12.4	13.9	24.1	209
SEm±	0.03	0.05		0.2	0.2	0.3	0.5	2
CD (P=0.05)	0.08	0.17		0.7	0.6	0.8	1.5	5

* $\sqrt{(x+1)}$ transformed ones before parentheses; **original values in parentheses

recorded significantly higher weed biomass than zero tillage. Among the weed-management practices, atrazine + 1 hand-weeding resulted in the minimum weed biomass (12.86 g/m^2) at maturity with weed-control efficiency of 84%. All other weed-management practices, exhibited significantly higher weed biomass than atrazine + 1 hand-weeding. The efficacy of atrazine alone compared to atrazine + 1 hand-weeding was less, because atrazine was able to manage weeds up to 30 days and after which its efficacy decreased (Intodia *et al.,* 1996). Integration of manual weeding with atrazine provided season-long weed management in maize and tackled new flushes of weeds.

Among the tillage-management practices, zero tillage resulted in the longest cob (18.4 cm), the thickest cob with girth of 14.3 cm, the maximum of 16.5 grain rows/ cob and the heaviest grain with test weight of 258 g/1,000 grains. Among the weed-management practices, atrazine + 1 hand-weeding proved the best having the longest cob (19.7 cm), the thickest cob with girth of 15.1 cm, the maximum of 17.9 grain rows/cob, the maximum of 35.4 grains/ row and the heaviest grain with test weight of 277 g/1,000-grains. The superior yield attributes in zero tillage among tillage practices and atrazine + 1 hand-weeding at 30 DAP among the weed-management practices were owing to reduced biomass of weeds. Sharma and Gautam (2003) reported the maximum 1,000-grain weight with application of atrazine at 1.0 kg/ha under zero-till condition.

Among the tillage practices, zero tillage resulted in the maximum grain yield of 6.73 t/ha and minimum tillage was at par, whereas conventional tillage showed significantly less grain yield (Table 2). The maximum grain yield in zero tillage was owing to advanced planting, better crop growth and superior yield attributes. Saharawat *et al*. (2010) reported higher yields from rainy (*kharif*) and winter season (*rabi*) maize under zero tillage owing to timely planting. Singh *et al.* (2015) reported higher green cob yield of no-till maize compared to conventionally tilled maize in summer. Among the weed-management practices, atrazine + 1 hand-weeding at 30 DAP resulted in the maximum grain yield of 7.62 t/ha and all the other weed-management practices including atrazine 1.25 kg/ha as pre-emergence spray alone recorded significantly less grain yield than atrazine + 1 hand-weeding. Dutta (2016) reported higher baby corn yield with atrazine 2.0 kg/ha + 1 hand-weeding at 30 DAS compared to atrazine 2.0 kg/ha as pre-emergence spray alone. The unhindered growth of weeds in weedy check reduced grain yield by 43% compared to atrazine + 1 hand-weeding. Interaction effects of tillage and weed management on yield of grain were significant. Zero tillage gave the maximum grain yield of 6.73 t/ha and atrazine + 1 hand-weeding resulted in the maximum grain yield of 7.62 t/ha, but atrazine + 1 hand-weeding under zero tillage gave the grain yield of 8.08 t/ha owing to synergism between the two factors.

Zero tillage provided the maximum stover yield of 8.78 t/ha and minimum tillage was at par. Among the weed-management practices, atrazine + 1 hand-weeding resulted in the maximum stover yield of 9.62 t/ha. The maximum stover yield under zero tillage, atrazine + 1 hand-weeding and atrazine + 1 hand-weeding under zero tillage were 8.78, 9.62 and 10.10 t/ha respectively.

Among the tillage practices, zero tillage resulted in the maximum net return of ₹69.7 ×10^3/ha. This tillage practice recorded lower cost of cultivation by savings in the fuel and labour and higher gross return by increasing yield of grain and stover than the other tillage practices. This is in agreement with the findings of Saharawat *et al.*(2010). Minimum tillage recorded 10.3% less net return than the zero tillage and the conventional tillage recorded 14.4% less net return than the minimum tillage. Among the weed-management practices, atrazine + 1 hand-weeding gave the maximum net return of 79.3 ×10^3 ₹/ha owing to the maximum yield and gross return. Ultimately, zero tillage showed benefit: cost (B:C) ratio of 3.48 among the tillage treatments and atrazine + 1 hand-weeding among weed-management practices resulted in the maximum B:C ratio of 3.62. Kamble *et al.* (2005) recorded the maximum benefit : cost ratio of 3.68 : 1 by pre-emergence applica-

Table 2. Effect of tillage methods and weed management on grain yield (t/ha) of summer maize

Treatment	W_1	W_2	W_3	W_4	W_5	W_6	Mean
			Grain yield (t/ha)				
T_1 : CT	5.92	4.78	7.11	7.21	6.67	3.74	5.91
T_2 : MT	6.32	5.13	7.33	7.57	7.23	4.61	6.37
T_3 : ZT	7.08	5.76	7.65	8.08	7.16	4.65	6.73
Mean	6.44	5.22	7.36	7.62	7.02	4.33	6.33
SEm±		T = 0.15, W = 0.08, T × W = 0.27, W × T = 0.13					
CD (P=0.05)		T = 0.59, W = 0.22, T × W = 0.96, W × T = 0.38					

CT, Conventional tillage; MT, minimum tillage; ZT, zero tillage; T, tillage methods; W, weed-management; T × W, T within same or different W; W×T, W within T

Table 3. Correlation between weed biomass, yield attributes and stover yield and grain yield

Parameter (X)	Yield (Y)	Correlation coefficient (r)
Weed biomass at maturity	Yield	–0.856**
Cob length	Yield	0.974**
Cob girth	Yield	0.893**
Grain rows/cob	Yield	0.960**
Grains/row	Yield	0.985**
Grain weight/cob	Yield	0.995**
Test weight	Yield	0.987**
Stover yield	Yield	0.981**

ϕ non-significant

tion of atrazine + 1 hoeing at 20 DAS. Kumar *et al.* (2013) reported higher net return and B:C ratio in zero-tillage than the conventional tillage. The interaction effects of tillage and weed-management practices were found significant for net return and B:C ratio. Among the treatment combinations, atrazine + 1 hand-weeding under zero tillage proved to be the best with the maximum net return of 88.4 × 10^3₹/ha and the maximum B:C ratio of 4.07. Visalakshi and Sireesha (2015) studied the effect of tillage practices on performance of maize after rice and reported higher net return in zero tillage than the conventional tillage. Stanzen *et al.*, (2016) reported lower cost of cultivation and higher B:C ratio with zero tillage in maize in maize–wheat cropping system.

Dry weight of weeds at maturity exhibited significant negative correlation with grain yield, whereas grain yield revealed significant positive correlation with yield attributes, stover yield and harvest index (Table 3). The yield attributes like cob length, cob girth, grain rows/cob, grains/ row, test weight, stover yield and harvest index showed significant positive correlation with grain yield at 1% level of significance. It is concluded that atrazine + 1 hand-weeding under zero tillage was found to be the best with the maximum yield and net return from hybrid maize in summer.

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