



Weed growth, yield and nutrient uptake in maize (*Zea mays*) as influenced by tillage, seed rate and weed control method

C.K. SARMA* AND R.C. GAUTAM

College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand

Received: November, 2009

ABSTRACT

A field experiment was conducted during *kharif* seasons of 2004 and 2005 at Pantnagar to study the effect of two tillage, three seed rate and four weed control methods on weed growth, yield and nutrient uptake in maize (*Zea mays* L.). There was significant increase in grain yield with conventional tillage (23.5% on mean basis) due to reduced population and dry weight of weeds when compared with no-tillage (3.69 t/ha). Grain yield recorded with 24 kg seed/ha was significantly higher (10%) when compared with the yield recorded with 16 kg seed/ha in 2005. However, net returns were higher in maize sown with a seed rate of 24 kg/ha in both the years. Similarly, two hand weedings at 25 and 45 days after sowing (DAS) recorded significantly higher grain yield (26% in 2004 and 68% in 2005) and nutrient uptake and reduced the population and dry weight of weeds as compared to weedy check. Two hand weedings at 25 and 45 DAS with higher seed rate (24 kg/ha) under tilled condition appeared to be the best in producing yield of maize, reducing weed growth and for enhanced profits.

Key words: Economics, Maize, Nutrient uptake, Seed rate, Tillage, Weed control, Yield

Maize (*Zea mays* L.) is one of the most important cereals grown over diverse environment and geographical ranges for human food, feed and fodder for livestock and raw materials for industries. In Uttarakhand, total area under this crop is 43 thousand ha, producing 65 thousand t with average productivity of 1.5 t/ha. Tillage is a critical practice in crop production as it provides favourable conditions for crop growth and development. It is reported that the normal tillage may not be required for getting optimum crop yield (Carter *et al.*, 2002). Thus, conservation tillage practices *viz.*, minimum tillage or no tillage system are gaining importance in recent years and challenging the need of tillage operations in maize. Yield of a crop is dependent on final plant population and therefore, establishment of optimum plant population is essential for higher yield, especially under conservation tillage. Rainy season maize suffers from severe weed competition and depending upon the intensity, nature, stages and duration of weed infestation causes yield losses varying from 28 – 100% (Patel *et al.*, 2006). Manual weeding is often difficult due to inadequate supply of labour in time, higher cost and non workable condition of the field. In such situations, use of

herbicide is an obvious choice. Tillage also affects the soil-weed seed bank and efficacy of herbicides. Hence, the present investigation was planned to find out the effect of different tillage methods, seed rates and weed control practices on weed growth and productivity of maize.

MATERIALS AND METHODS

Field experiments were conducted at Crop Research Centre, Pantnagar (29° N latitude, 79° 29' E longitude and 243.8 m altitude), Uttarakhand during *kharif* seasons of 2004 and 2005 at the same site. The soil of the experimental site was clay-loam in texture, neutral in soil pH (7.4), low in available nitrogen (236.0 kg/ha), medium in available phosphorus (19.4 kg/ha) and high in available potassium (283.5 kg/ha). Twenty four treatments comprised of combinations of two tillage practices – [conventional tillage (CT) and no-tillage (NT)], three seed rates [16, 20 (existing seed rate) and 24 kg/ha] and four weed control methods [hand weeding at 25 and 45 days after sowing (DAS), 'paraquat' 0.75 kg ai /ha at 25 DAS, 'paraquat' at 45 DAS and weedy check] were tested in a split-plot design and replicated thrice. Tillage and seed rates were kept in main-plots and weed control methods in sub-plots. In tilled treatment, three harrowings followed by planking was done. Under no-tilled condition, crop was sown directly and 'paraquat' @ 0.75 kg ai /ha was sprayed one

*Corresponding author (E mail: drcksarma@gmail.com)

*Correspondence address: Subject Matter Specialist, KVK, Bongaigaon, Assam Agricultural University, Kajalgaon-783 385

week before sowing of the crop to kill the existing weeds. Hand weeding was done with the help of 'khurpi' and 'paraquat' was applied as directed spray in the inter row spaces of maize. Seeds of composite maize 'Gaurav' were dibbled as per the treatment at 4-5 cm depth in furrows opened 60 cm apart with the help of tractor drawn furrow opener on 4 July and 23 June during 2004 and 2005, respectively. Recommended package of practices were followed for raising the crop. The crop was harvested on 30 September in 2004, and 20 September in 2005. Total amount of rainfall received during crop seasons of 2004 and 2005 was 1,587.2 and 1,095.6 mm, respectively, of which maximum amount (573 mm in 2004 and 538.2 mm in 2005) was received in August. Observation on weed density and weed dry weight were recorded at knee high stage by placing a quadrat of 0.50 m x 0.50 m at four places in each plot for collection of weed samples. Energy equivalent of different inputs and energy coefficient of various equipments and produces were used for calculating energy input and output. Cost of cultivation and gross return were calculated on the basis of prevailing market prices of different inputs and produces, respectively.

RESULTS AND DISCUSSION

Weed growth

Dominant weed species present in the experimental site were *Cynodon dactylon* L. (21%), *Cyperus rotundus* L. (15%), *Echinochloa crusgalli* L. (12%), *Echinochloa colonum* L. (13%), *Agropyron repens* L. (11%), *Parthenium hysterophorus* L. (9%), *Digitaria sanguinalis* L. (8%), *Eclipta alba* L. (5%), *Euphorbia hirta* L. (4%) and *Commelina benghalensis* L. (2%). Tillage operation resulted in a significant reduction in all the major weed species as compared to no-tillage at knee high stage (Table 1). Significant reduction in *Cynodon dactylon* population was observed with 24 kg seed/ha as compared to 16 kg seed/ha. Population of all major weed species were also significantly reduced due to two hand weedings and 'paraquat' application at 25 DAS when compared with paraquat application at 45 DAS and weedy check.

Total weed population (43.9%) and weed dry weight (42.8%) recorded under tilled plots were significantly lower than weed population (56.1%) and weed dry weight (57.2%) recorded under no-tilled plot which might be due to killing of emerged weeds prior to sowing and subsequently, lesser emergence of weeds (Table 1). Similarly, increasing seed rate from 16 kg to 24 kg/ha reduced the density and dry matter of weeds. More competitive efficiency of crop at higher seed rate might have resulted in lower weed growth (Kumar and Walia, 2003). All the weed control methods except paraquat application at 45 DAS caused significant reduction in density and dry

weight of weeds over weedy check. Minimum weed density (4.0%) and weed dry weight (3.3%) were observed under two hand weedings at 25 and 45 DAS.

Growth and yield attributes of maize

Growth and yield attributes were significantly influenced by different tillage practices, seed rates and weed control practices (Table 2). Significant improvement in plant height (19.7%) and dry matter accumulation in plant (23.7%) at maturity stage was observed due to tillage operation over no-tillage. Plant stand recorded at harvest was significantly higher (10.2%) under tilled treatment over no-tilled. Improvement in yield attributes viz., number of effective plants (15.0%), grains/cob (15.6%), shelling percent (3.8%) and test weight (3.0%) were also significant due to tillage operation as compared to no-tillage. Favourable soil physical conditions for seed germination, seedling emergence, stand establishment and subsequent growth might have contributed to higher values of growth and yield attributes under tilled treatment. Maximum plant height, dry matter accumulation (151.4 g/plant) were observed with 16 kg seed/ha; however, plant stand were highest with 24 kg seed/ha. Plant height and dry matter accumulation under two hand weedings were significantly higher as compared to rest of the weed control treatments. Similarly, two hand weedings resulted in significantly higher plant stand, grains / cob, shelling per cent and test weight over rest of the treatments except 'paraquat' application at 25 DAS in respect of grains/cob.

Tillage resulted in significant improvement in grain (14% in 2004 and 33 % in 2005) and biological yield (11% in 2004 and 24 % in 2005) of maize as compared to no-tillage (Table 3). Favourable soil physical conditions for growth and development as well as lesser crop-weed competition might have contributed to higher values of yield attributes under tilled treatment which contributed to higher yield. Significantly higher grain yield was recorded with 20 kg (6%) and 24 kg seed/ha (10%) in comparison to 16 kg seed/ha during 2005. Higher values of yield attributes at lower plant population could not overcome the effect of higher number of effective plants at higher seed rate in increasing crop yield. Improvement in biological yield was also observed with 24 kg seed/ha (5% in 2004 and 10% in 2005) as compared to 16 kg seed/ha. All the weed control methods resulted significant increase in grain and biological yields over weedy check except paraquat application at 45 DAS in respect of biological yield during 2004. Maximum grain and biological yields were recorded with two hand weeding treatment during both the years. Lower crop-weed competition under two hand weeding might have led to better yield components and thus resulted in higher yield (Mundra *et al.*, 2003).

Interaction effect of tillage and weed control method on grain yield was found significant during both the years (Table 4). Maximum grain yield was observed under two hand weeding under both till and no-till conditions. Significantly higher grain yield was noted with two hand weeding under till condition as compared to grain yield

recorded under all other tillage and weed control methods except paraquat application at 25 DAS under till condition. Similarly, grain yield noted with paraquat application at 25 DAS under till condition was significantly higher than the grain yield recorded under rest of the weed control methods under no-till condition, however, it was com-

Table 1. Effect of tillage, seed rate and weed control methods on population of major weed species, total weed density and weed growth in maize crop at kneehigh stage (Average data of two years)

Treatment	Weed population(No/m ²)					Total weed density (No/m ²)	Weed dry weight (g/m ²)
	<i>Cynodon-dactylon</i>	<i>Cyperus-rotundus</i>	<i>Echinochloa crus-galli</i>	<i>Echinochloa-colonum</i>	<i>Agropyron repens</i>		
<i>Tillage method</i>							
Tilled	34.2	22.6	19.5	23.2	19.1	11.08 (155.8)	6.83 (60.4)
No-tilled	44.4	34.8	25.0	29.5	23.5	12.49 (198.5)	8.01 (80.7)
SEm±	1.1	1.8	1.1	2.0	1.2	0.27	0.22
CD (P = 0.05)	3.3	5.5	3.4	6.1	3.7	0.86	0.69
<i>Seed rate (kg/ha)</i>							
16	48.5	36.1	29.2	35.3	31.5	12.10 (185.7)	7.68 (75.6)
20	43.5	33.4	28.8	30.2	28.6	12.01 (185.8)	7.42 (70.3)
24	42.0	29.5	26.6	27.4	27.2	11.24 (160.0)	7.16 (65.6)
SEm±	1.3	2.2	1.3	2.5	1.4	0.33	0.27
CD (P = 0.05)	4.1	NS	NS	NS	NS	NS	NS
<i>Weed control method</i>							
Two hand weedings	8.2	6.1	5.5	5.7	4.5	5.34 (31.4)	2.97 (9.4)
Paraquat at 25 DAS	9.4	7.3	5.5	6.3	5.1	6.35 (41.9)	4.27 (18.6)
Paraquat at 45 DAS	60.6	56.2	47.0	44.5	44.5	17.67 (315.3)	11.21 (127.0)
Weedy check	62.4	57.5	54.5	42.6	40.5	17.79 (319.9)	11.22 (127.0)
SEm±	1.6	1.7	2.5	1.7	2.0	0.33	0.12
CD (P = 0.05)	4.7	4.9	7.8	4.9	6.4	0.96	0.33

DAS, Day after sowing; Data subject to square root transformation; Values in parentheses are original value

Table 2. Effect of tillage, seed rate and weed control methods on growth and yield attributes of maize (Average data of two years)

Treatment	Plant height at maturity (cm)	Dry matter accumulation at maturity (g/plant)	Plant stand at harvest (,ooo/ ha)	Effective plants (,ooo/ha)	Grains/cob	Shelling percent	1,000-grain weight (g)
<i>Tillage method</i>							
Tilled	174.1	163.3	71.5	66.5	429	81.5	209.3
No-tilled	145.5	132.0	64.9	57.8	371	78.5	203.2
SEm±	0.7	1.0	1.1	0.9	7	0.3	1.3
CD (P = 0.05)	2.2	3.3	3.3	2.8	23	1.0	4.2
<i>Seed rate (kg/ ha)</i>							
16	161.6	151.4	57.4	52.9	413	80.6	207.7
20	160.9	148.2	68.2	62.2	404	79.8	206.3
24	157.9	143.5	79.0	71.5	383	79.5	204.8
SEm±	0.9	1.3	1.3	1.1	9	0.4	1.6
CD (P = 0.05)	2.7	4.0	4.1	3.4	NS	NS	NS
<i>Weed control method</i>							
Two hand weedings	169.3	167.7	76.9	72.3	433	81.6	220.1
Paraquat at 25 DAS	161.0	153.0	69.8	64.1	408	79.7	208.0
Paraquat at 45 DAS	156.5	148.7	65.3	58.8	388	79.6	200.7
Weedy check	152.4	121.4	60.8	55.4	369	79.0	196.2
SEm±	0.8	1.4	1.6	1.4	14	0.4	1.5
CD (P = 0.05)	2.3	4.1	4.7	4.1	41	1.0	4.3

parable with two hand weeding treatment under no till condition during 2005.

Nutrient uptake

Significantly higher uptake of nitrogen (12%), phosphorus (17%) and potassium (11%) were observed under tilled condition in comparison to no-tilled condition which may be attributed to lower grain and stover yield under no-tilled condition (Table 3). Under no-till condition, soil tends to be cooler, wetter and less aerated which may influence plant nutrient absorption by slowing root growth and reducing plant nutrient release from organic materials

(Blevins and Fryr, 1998).

Seed rates have no significant influence on nutrient uptake. All the weed control practices resulted in significantly higher uptake of plant nutrients over the weedy check. Hand weeding twice had the highest NPK uptake. Favourable growth conditions as well as lower crop - weed competition contributed to this higher uptake.

Energy out put-input ratio and Economics

Higher energy output - input ratio was observed under till condition as compared to no-till condition which might be attributed to higher energy output under till condition

Table 3. Effect of tillage, seed rate and weed control methods on total uptake of nutrients, yield, energy out put-input ratio and economics in maize (Average data of two years)

Treatment	Total uptake by maize(kg/ha)*			Grain yield (t/ha)		Biological yield (t/ha)		Energy output-input ratio**(Rs/ha)**	Cost of cultivation (Rs/ha)**	Net return (Rs/ha)**	B : C Ratio**
	N	P	K	2004	2005	2004	2005				
Tillage method											
Tilled	98.3	24.7	100.9	4.82	4.18	10.96	10.16	9.9	10,499	15,901	1.51
No-tilled	88.1	21.1	91.2	4.23	3.14	9.88	8.18	9.6	9,668	10,756	1.09
SEm±	1.2	0.3	1.2	0.04	0.05	0.11	0.15				
CD (P = 0.05)	3.7	1.0	3.7	0.13	0.17	0.35	0.46				
Seed rate (kg/ ha)											
16	91.8	22.7	93.7	4.45	3.46	10.18	8.72	9.3	9,940	12,374	1.22
20	92.3	22.9	95.6	4.51	3.67	10.37	9.22	9.8	10,084	13,477	1.31
24	95.4	23.1	98.2	4.63	3.82	10.70	9.58	10.2	10,228	14,135	1.36
SEm±	1.4	0.4	1.5	0.05	0.07	0.14	0.18				
CD (P=0.05)	NS	NS	NS	NS	0.21	0.43	0.57				
Weed control method											
Two hand weedings	103.0	26.3	104.7	5.04	4.70	11.38	11.20	12.0	11,167	18,155	1.62
Paraquat at 25 DAS	97.2	24.1	99.4	4.75	3.94	10.81	9.68	10.6	10,096	14,912	1.47
Paraquat at 45 DAS	89.7	21.5	93.0	4.33	3.19	9.90	8.31	8.6	10,096	10,672	1.04
Weedy check	82.7	19.6	86.9	4.00	2.80	9.40	7.51	7.9	8,977	9,574	1.05
SEm±	1.1	0.4	1.2	0.05	0.06	0.19	0.19				
CD (P=0.05)	3.2	1.1	3.4	0.15	0.17	0.57	0.54				

DAS, Day after sowing * Pooled data **: Mean data

Table 4. Interaction effect of tillage and weed control method on grain yield (t/ha) of maize

Tillage method	Weed control method			
	Two hand weedings	Paraquat at 25 DAS	Paraquat at 45 DAS	Weedy check
2004				
Tilled	5.18	5.13	4.74	4.24
No-tilled	4.90	4.37	3.91	3.75
2005				
Tilled	5.07	4.17	3.89	3.58
No-tilled	4.33	3.70	2.49	2.02
2004 and 2005				
SEm±	0.08*	0.08		
CD (P=0.05)	0.22	0.23		

*For tillage at same or different weed control method

**For weed control method at same tillage method

due to higher yield (Table 3). Increase in energy output – input ratio was observed with the increase in seed rate from 16 kg to 24 kg/ha. Among the weed control methods, two hand weedings resulted in highest energy output – input ratio.

Higher net return and B: C ratio was recorded due to tillage compared to no-tillage (Table 3). Higher seed rate (24 kg/ha) resulted in higher net return (Rs. 14,135/ha) and B: C ratio (1.36) when compared with 20 kg (Rs. 13,477/ha and 1.31) and 16 kg seed/ha (Rs. 12,374/ha and 1.22). Two hand weedings had the highest net return (Rs. 18,155/ha) and B: C ratio (1.62) as compared to rest of the weed control methods.

It may be concluded that conventional tillage, higher seed rate (24 kg/ha) and hand weeding at 25 and 45 days after sowing appeared to be the best in reducing weed growth, producing maximum yield and net return in maize.

REFERENCES

- Blevins, R.L. and Fryr, W.W. 1998. Conservation tillage: An ecological approach to soil management. *Advances in Agronomy* **51**: 33–37.
- Carter, M.R., Sanderson, J.A., Ivany, J.A. and White, R.P. 2002. Influence of rotation and tillage on forage maize productivity, weed species and soil quality of a fine sandy loam in the cool humid climate of Atlantic Canada. *Soil Tillage and Research* **67**(1): 85–98.
- Kumar, B. and Walia, U.S. 2003. Effect of nitrogen and plant population level on competition of maize (*Zea mays* L.) with weeds. *Indian Journal of Weed Science* **35**(1 and 2): 53–56.
- Mundra, S.L., Vyas, A.K. and Maliwal, P.L. 2003. Effect of weed and nutrient management on weed growth and productivity of maize (*Zea mays* L.). *Indian Journal of Weed Science* **35**(1 and 2): 57–61.
- Patel, V.J., Upadhyay, P.N., Patel, J.B. and Meisuriya, M.I. 2006. Effect of herbicide mixture on weeds in *kharif* maize (*Zea mays* L.) under middle Gujarat conditions. *Indian Journal of Weed Science* **38**(1 and 2): 54–57.