Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2016, Volume 29, Issue 2, Page 124-129

Evaluation of Maize Cultivars for their Suitability under Organic Production System in North Eastern Hill Region of India

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ARTICLE INFO

Article history:
Received 6 February 2016
Revision Received 8 March 2016
Accepted 9 March 2016

Key words:
Maize, Organic food, Soil organic carbon, Disease severity

ABSTRACT

The hill ecosystem of North Eastern region (NER) of India is suitable for organic farming due to very less use of fertilizer and agrochemicals, abundance of organic manure and favourable soil and climatic conditions. Maize is the most potential and predominant rainy season crop in the upland ecosystem of NER. A field experiment was carried out during *kharif seasons* of 2013 and 2014 to identify suitable maize cultivars having short duration and high yield potential under organic production system. Eleven varieties/ lines of maize comprising eight composites, one hybrid and two local lines were evaluated. Significantly, the highest chlorophyll index at 60 days after sowing (DAS) was recorded in the variety DA 61A followed by RCM 1-3 in both the years of experimentation. Cob weight was maximum in variety DA 61 A (221.8 and 223.8 g/cob in year 2013 and 2014, respectively). The highest grain yield was recorded in variety DA 61 A (3.33 t/ha and 3.39 t/ha in year 2013 and 2014, respectively) followed by RCM- 76 (3.26 t/ha and 3.29 t/ha). The highest soil organic carbon (SOC) was recorded under variety DA 61 A and RCM-75 (2.11 %) followed by RCM-1-3 and RCM 76 (2.10 %). For green cob production, RCM-75 and RCM-76 (75-80 days) recorded the shortest crop duration followed by DA 61A (80 days) and RCM 1-2 (85 days). However, for seed production, DA 61A took 110 days duration followed by RCM 1-2 (115 days). Local lines took 125-130 days for seed production. Cultivar DA 61 A registered the least Turcicum leaf blight severity with moderate severity for Maydis leaf blight and rust than other varieties. Thus, it can be concluded that DA 61A and RCM-76 cultivars of maize are most suitable for growing in hill conditions of NER under organic production system.

1. Introduction

Maize (*Zea mays* L.) is the most important crop worldwide for food, feed and bioenergy production. Maize is the third most important food grain in India after wheat and rice. Its importance lies in the fact that it is not only used for human food and animal feed but at the same time it is also widely used for corn starch industry, corn oil production, baby corns *etc*. In India, about 28% of maize produced is used for food purpose, about 11% as livestock feed, 48% as poultry feed, 12% in wet milling industry (for example starch and oil production) and 1% as seed. Productivity of maize has increased from 1.9 t/hectare in 2004-05 to 2.5 t/hectare in 2013-14.

Maize is the most potential and predominant rainy season crop in the hills of North Eastern Region (NER) of India (Das *et al.,* 2010). Maize is cultivated in an area of about 0.17 M ha with productivity of 1.50 t/ha in the region, which is below India's national average productivity of 2.5 t/ha. The low maize productivity is mainly due to inadequate plant nutrition and cultivation of local cultivars (Layek *et al.,* 2015). Organic food production is gradually gaining momentum worldwide. Emerging from 42,000 ha under certified organic farming during 2003-04 in India, the organic agriculture has grown almost 29 fold during the last 5 years. The recycling and the use of nutrients from organic manure have been given more consideration for ensuring sustainable land use in agricultural development.

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Organic farming is considered as one of the best option for protecting and sustaining soil health and produce healthy food (Das *et al.,* 2010). Higher levels of total soil organic carbon (SOC), total nitrogen (N), soluble phosphorous (P) and microbial activity were reported from soils under organic production system (Mader *et al.,* 2002). Organic manure increases soil productivity by enhancing the soil's physical, chemical and biological properties (Patel *et al.,* 2014). Although grain yields under organic farming is often lower than that under conventional farming, it is feasible to have increased yields under the former especially in hills. In view of growing demand for organic food products worldwide including India, the NER of India has vast opportunity to emerge as major suppliers of organic products. By March 2011, India had brought about 4.43 million ha area under organic certification process (Yadav 2012). The NER has numerous advantages to go for organic food production, such as minimum use of fertilizer specially in hills (<12 kg ha^{-1}), availability of plant- and livestock-excreta-based organic manure and pesticides, and favourable climatic conditions for growing a wide range of crop species. The net cultivated area of the NER is about 4 million ha and the estimated availability of organic manure is about 46 million mega gram (Mg) which is almost sufficient for the region to go organic (Bujarbaruah 2004).

Cultivation of exhaustive crops such as maize without proper nutrient management exacerbate the degradation process, making the soil unfit for cultivation. Response of varieties to organic input are not similar. For getting desired result from organic farming, organic input responsive varieties are to be identified. Thus necessitating the need for identifying suitable maize cultivars along with location specific package of practices for sustainable organic hill agriculture. Hence, this study was conducted to identify maize varieties with high yield and resistance to pest and diseases under organic production system.

2. Materials and Methods

Description of the site

Field experiments were conducted for two consecutive years (2013 and 2014), in the Agronomy farm of the Indian Council of Agricultural Research (ICAR) Research Complex for North Eastern Hill (NEH) Region, Umiam, Meghalaya, India under Network Project on Organic Farming (NPOF). The experimental site was a valley land (950 m a.s.l., 25°30´ N latitude and 91°51´ E longitude) surrounded by hillocks. The experimental site (Umiam) is characterized by a subtropical climate. The area received a good amount of rainfall (2450 mm) most of which is received in rainy season starting from May and extended up to the month of October. Daily mean temperature during the monsoon season (June to October) ranges from 23 – 32^0C. The average annual rainfall of the site is 2450 mm. The soil of the experimental site is a *Typic Paleudalf*, clay loam in nature, acidic in reaction (pH 5.3), low in available N (253.7 kg/ha) and P (11.2 kg/ha) and medium in available potassium (K) (259.9 kg/ha).

Treatments and lay out

The experiment consisted of eleven varieties/ lines of maize among which eight were composites, one hybrid and two local lines. The experimental field was prepared by using power tiller followed by levelling during March. Maize was sown with the onset of monsoon showers in the month of April with spacing of 50 cm row to row and 25 cm plant to plant. Well-decomposed FYM (containing 0.5% N and 0.2% P_2O_5 approx.) were applied as basal on the basis of nitrogen (N) equivalent to meet the requirement (60:60:40 kg N, P_2O_5 and K_2O/ha) and P requirement was supplemented through rock phosphate. Supplementation of P is necessary as the soil in this region is acidic and P availability is very low. The experiment was laid out in randomized block design (RBD) and replicated thrice. The gross plot size was 5.0 m x 4.0 m.

Plant sampling

Five plants, randomly sampled from each plot, were tagged and plant height was measured from the base of the stem to the tip of the longest tassel branch. The chlorophyll index of maize leaf was measured at 30 days after sowing (DAS) and 60 DAS by SPAD meter. The yield parameters of maize (cob length, con weight *etc.*,) grain yield and stover yield were recorded at harvest. The harvest index (HI) was determined by the following formula and expressed as percentage (%).

HI = (Economic yield/biological yield) × 100
Economic yield = seed/grain yield
Biological yield = Grain yield + stover yield

Soil analysis

Initial as well as post-harvest composite soil samples were collected (500 g composite sample, one sample from each plot) from 0–15 cm depth. The soil samples were air dried, processed using 2 mm sieve and analyzed for soil pH by Piper (1950), SOC by Nelson and Sommers (2005), available N by the alkaline permanganate method (Subbiah and Asija 1956); available P by Bray method (Bray and Kurtz, 1945) and available K by neutral normal

NH_4OAC extraction method (Knudsen *et al.,* 1982). Bulk density (BD) was determined by the core method (Blake and Hartge 1986) using cores of 5.8 cm height and 5.4 cm.

Disease intensity

The intensity of TLB (Turcicum leaf blight), MLB (Maydis leaf blight) and rust in maize were also studied. The TLB caused by *Exserohilum turcicum*, while the MLB caused by *Drechslera maydis* and rust caused by *Puccinia sorghi* and *Puccinia polysora*. The TLB, rust and MLB intensity were assessed using a key adopted from Mayee and Datar 1986; Danson *et al.* (2008). Percent disease index (PDI) of TLB, rust and BLB was worked out by using the formula given by Wheeler (1969)

$$PDI = \frac{\text{Sum of individual ratings}}{\text{No. of plants examined x Maximum disease scale}} \times 100$$

Statistical analysis

The experimental data pertaining to each parameter of study were subjected to statistical analysis by using the technique of analysis of variance and their significance was tested by "F" test (Gomez and Gomez 1984). Standard error of means (SEm+) and least significant difference (LSD) at 5% probability (p=0.05) were worked out for each parameter studied to evaluate differences between treatment means.

3. Results and Discussions

Growth

Growth behaviour of the crop plant is reflected by the final height of the plants at maturity. Plant height at harvest was significantly influenced by varieties in both the years (Table 1). Plant height was the highest in RCM 75 (251.8 cm) followed by RCM 1-3 (248.3 cm) and Hemant (246.3 cm) whereas, QPM 9 (210.0 cm) recorded the shortest plant height followed by DA 61 A (222.9. cm) and local yellow (224.1cm). Very lengthy plant often lodged due to wind and causes significant yield loss. The chlorophyll index (CI) of maize leaves differ significantly among varieties at 30 and 60 DAS. Significantly, the highest CI at 60 DAS was recorded in variety DA 61 A followed by RCM 1-3 and RCM-76 and minimum CI was found in the variety RCM 1-1 in both 30 and 60 DAS during both the years of experimentation. This increase in chlorophyll content in leaves can be attributed to better nutrition under organic production system and varietal characters.

Table 1. Plant height and chlorophyll index of different varieties of maize under organic production system

Maize cultivars	Plant height at Harvest (cm)		Chlorophyll index				Duration (days)		TLB (%)*	Rust index (%)*	MLB (%)*
			30 DAS		60 DAS		Green cob	Seeds			
	2013	2014	2013	2014	2013	2014					
RCM-1-1	246.9	246.0	34.7	35.9	43.3	43.1	90-95	110-115	16.3	7.4	12.5
RCM- 1-2	233.5	233.2	37.3	36.9	45.8	45.3	85	115	14.9	13.7	9.07
RCM-1-3	255.1	248.3	40.1	41.6	47.3	47.1	95	125	14.7	11.6	11.2
RCM-75	257.1	251.8	37.7	38.9	46.3	45.8	75-80	105-110	18.7	9.7	11.5
RCM-76	234.5	232.9	38.2	38.5	46.5	46.3	75-80	105-110	17.1	13.3	9.6
Vijay composite	246.5	234.4	37.3	36.8	44.5	45.0	85-90	115-115	9.3	15.8	10.4
Hemant	241.2	246.3	37.3	36.4	44.8	43.6	80-85	110-115	9.6	10.5	13.1
DA 61 A	228.2	222.9	40.1	41.7	48.0	48.2	80	110	9.1	8.4	9.2
QPM 9	217.6	210.0	35.5	35.4	44.0	45.2	70-75	90-95	12.5	8.6	15.7
Local Yellow	226.5	224.1	37.8	37.6	44.3	44.5	95-100	125-130	19.5	12.2	9.9
Local White	233.1	234.4	38.9	39.0	44.7	44.9	95-100	125-130	12.3	7.2	14.9
SEm+	4.99	5.25	0.98	1.03	0.88	0.89	-	-	0.58	0.42	0.65
CD (*p*=0.05)	13.35	15.50	2.88	3.05	2.60	2.63	-	-	1.73	1.26	1.94

*Average value

DAS=Days after sowing, TLB =Turcicum leaf blight, MLB = Maydis leaf blight

Crop duration

Crop duration of different varieties revealed that for green cob production, the variety RCM-75 and RCM-76 (75-80 days) required shortest duration followed by DA 61A (80 days) and RCM 1-2 (85 days) (Table 1). However, shortest crop duration was recorded for variety QPM 9 (70-75 days) but the yield of this variety was found very low as compared to other varieties. Longer crop duration was found in the local varieties (95-100 days) as compared to the improved ones. Crop duration for seed production of different varieties followed similar trend to that of green cob. The DA 61 A took 110 days duration for seed production followed by RCM 1-2 (115 days). Local varieties took 125-130 days to mature for seed production.

Disease severity/intensity

The study indicated that there was clear cut differential disease response of maize varieties under organic production system (Table 1). Among the varieties, DA-61A (PDI=9.1) followed by Vijay composite (PDI=9.3) and Hemant (PDI=9.6) showed the lower disease severity for TLB as compared to others. In case of rust, the least disease severity was recorded with local white (PDI=7.2) followed by RCM-11 (PDI= 7.4) and DA-61A (PDI=8.4). While, for MLB, least disease pressure was recorded with cultivar RCM-12 (PDI = 9.1) followed by DA 61A (PDI=9.2) and RCM-76 (PDI=9.6). The cultivars like DA 61A, RCM 76 and Hemant might have some degree of tolerance to aforesaid diseases which ultimately helps in obtaining better yield under organic production system.

Yield attributes, yield and harvest index

Yield attributes and yield of maize were significantly influenced by varieties under organic production system (Table 2). The longest cob length was recorded with DA 61A (15.0 cm, 14.3 cm in year 2013 and 2014, respectively) in both the years followed by local yellow (14.4 cm, 14.8 cm) and the shortest cob length was recorded in the local white (11.4 cm, 11.0 cm). Cob weight was maximum in DA 61 A (221.8 and 223.8 g in year 2013 and 2014, respectively) followed by RCM-76 (212.7 g and 211.8 g). Green cob yield was maximum in variety RCM 1-3 (5.73 t/ha, 5.91 t/ha in year 2013 and 2014, respectively) followed by RCM 1-1. The highest grain yield was recorded in DA 61 A (3.33 t/ha and 3.39 t/ha, in year 2013 and 2014, respectively) followed by RCM- 76 (3.26 t/ha and 3.29 t/ha). Lower grain yield was recorded in local white (2.62 t/ha and 2.67 t/ha in year 2013 and 2014, respectively).

Table 2. Yield attributes and yields of different varieties of maize under organic production system

Maize cultivars	Cob length (cm)		Cob weight (g)		Green cob yield (t/ha)		Grain yield (t/ha)		Stover yield (t/ha)		Harvest index (%)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
RCM-1-1	13.3	13.3	213.5	210.8	5.09	5.10	3.11	3.07	7.21	7.13	30.1	30.1
RCM-1-2	12.7	12.8	200.5	201.6	4.65	4.68	2.95	2.94	6.90	6.86	30.0	30.0
RCM-1-3	13.3	13.3	208.8	212.8	5.24	5.28	3.15	3.27	7.99	8.01	28.3	29.0
RCM-75	13.7	13.8	217.4	219.4	5.46	5.50	3.19	3.26	7.52	7.98	29.8	29.0
RCM-76	13.7	13.7	212.7	211.8	5.33	5.36	3.26	3.29	7.90	7.98	29.2	29.2
Vijay composite	13.0	13.1	193.8	197.0	4.64	4.69	3.13	3.14	7.58	7.81	29.2	28.6
Hemant	12.5	12.6	184.0	190.9	4.60	4.61	2.93	3.01	6.97	7.19	29.5	29.5
DA 61 A	14.1	14.1	221.8	223.8	5.55	5.59	3.33	3.39	7.51	7.75	30.7	30.4
QPM 9	12.9	12.9	194.2	196.2	4.42	4.53	3.01	3.00	7.10	7.30	29.8	29.1
Local Yellow	12.5	12.6	176.1	179.5	3.92	3.90	2.75	2.78	6.89	6.93	28.6	28.8
Local White	11.9	11.8	162.6	164.7	3.76	3.84	2.62	2.67	6.74	6.83	27.9	28.1
SEm+	0.29	0.34	5.7	4.9	0.29	0.22	0.12	0.12	0.21	0.22	1.01	1.00
CD (p=0.05)	0.86	1.00	16.8	14.5	0.85	0.66	0.35	0.35	0.61	0.64	2.98	2.96

This may be due to better growth and their positive influence on the yield parameters than other varieties (Layek *et al.,* 2014). The greater number of cobs per plant, seeds per cob, cob weight in maize resulted in higher seed yield in these cultivars. Correlation of grain yield of maize with cob length and cob weight also showed positive co-relation (Fig. 1). The highest correlation was observed between grain yield and cob length (coefficient of determination R^2=0.92) followed by that between grain yield and cob weight (R^2=0. 0.89). Thus, it is important that while selecting for high grain yield, due weightage is given to these yield attributing characters. The harvest index determines how much photosynthates are transformed into economic yield. The harvest index was recorded non-significant among the varieties. However, the highest harvest index was found in the variety DA 61 A (30.7% and 30.4 % in year 2013 and 2014, respectively). Whereas, the minimum harvest index was found in the local variety local yellow and local white (27.9 % and 28.1%). As harvest index indicates the ratio between the economic parts (*i.e.,* in this case seeds) and total biomass production, varieties producing higher seed yield have recorded higher harvest index as compared to others (Layek *et al.,* 2014).

Soil chemical and physical properties

The SOC is considered as an indicator of N-supplying capacity of soils. It helps in economizing the external supply of N besides supplying a substantial proportion of N utilized by the crop from mineralizing soil organic matter. The highest SOC was recorded in soil under variety DA 61 A and RCM-75 (2.11 %) followed by RCM-1-3 and RCM 76 (2.10 %). But the difference was not statically significant (Table 3). Bulk density and soil pH under different varieties were also non-significant. It may be due to the fact that only two years of cultivation of different cultivars of maize may not have sufficient influence to change the soil pH and bulk density (BD). The available N and P content in the soil was non-significant due to different varieties. However, higher soil available N was observed under variety local yellow (213.7 kg/ha) followed by RCM 1-2 (213.6 kg/ha). It may be due to lower uptake of N from soil due to lower yield potential of these varieties. Application of FYM along with rockphosphate helps in proper nutrition and maintenance of soil fertility in maize fields when applied at proper doses replenishing the most deficient macro- and micro nutrients which in turn help in getting the optimum grain yield and harvest index of maize varieties. Organic manure were reported to improve the SOC, available N, P and K in soil, thereby sustaining the soil health (Das *et al.,* 2010).

Conclusion

From the study it can be concluded that there is very good scope for cultivation of high yielding varieties of maize under organic production system. Cultivars like DA 61 A and RCM-76 are most promising for organic production in terms of productivity (yielding more than 3.0 t/ha) and short duration for the north eastern hill region of India.

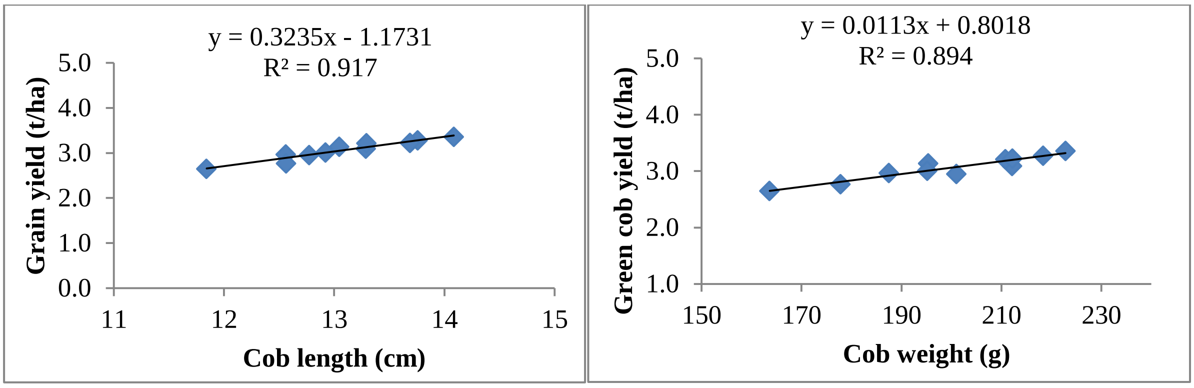
Acknowledgement

The authors are thankful to ICAR-Indian Institute of Farming System Research, Uttar Pradesh for providing financial and technical help under Network Project on Organic Farming (NPOF).

Table 3. Soil physical and chemical properties under different varieties of maize at 0-15 cm soil depth (after two years of cropping)

Maize cultivars	Soil pH	SOC (%)	Bulk density (Mg/cm^3)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
RCM-1-1	5.00	2.08	1.19	209.59	17.75	200.55
RCM-1-2	5.08	2.08	1.18	213.09	17.82	196.84
RCM-1-3	4.92	2.11	1.17	211.31	19.27	203.19
RCM-75	4.93	2.11	1.19	196.58	18.44	202.51
RCM-76	5.08	2.09	1.20	199.33	17.46	196.73
Vijay composite	5.05	2.09	1.21	202.48	18.10	194.62
Hemant	4.91	2.07	1.23	198.37	17.43	188.76
DA 61 A	4.97	2.11	1.19	197.83	18.21	200.58
QPM 9	5.05	2.07	1.22	196.18	16.87	193.85
Local Yellow	5.09	2.09	1.16	213.53	19.61	202.23
Local White	4.93	2.07	1.17	210.34	19.46	198.00
SEm+	0.04	0.02	0.03	2.71	0.98	4.00
CD (p=0.05)	NS	NS	NS	7.98	NS	NS

Figure 1. Correlation of grain yield with cob length and cob weight



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