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# Performance evaluation of maize cultivars for organic production

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**Abstract**
The field experiment was conducted to evaluate the suitability of maize cultivars for organic production. The performance of twelve different maize cultivars viz. Kanchan, Arawali, Sona-222, JM-8, JM-12, JM-216, Pratap-5, Pratap-6, Proagro-4412, CPGB-4202, Popcorn-1 and Sweetcorn in terms of yield, uptake and soil properties was assesses under organic farming. The selected maize cultivars were grown with 100 kg organic-N ha$^{-1}$ supplied through organic manures on nitrogen equivalent basis. The results of the present study showed that the maize cultivar Proagro-4412, Kanchan, JM-12, JM-8, Pratap-6, Arawali, Pratap-5 resulted in higher yield among the studied cultivars. However the optimum yield was not obtained as the yield ranged to the tune of 3.4 to 3.5 t ha$^{-1}$. The cultivar Popcorn-1 and Sweetcorn were the least responsive cultivars under organic farming. Kanchan removed maximum nitrogen from soil followed by Proagro-4412, and JM-12 cultivars. The range of N uptake by cultivars is relatively lower as it varied between 28.1 and 61.6 kg/ha. It indicates that the supply of N from organic manure may not have met the crop demand of most of the cultivars. The P and K removal also followed almost similar trends in cultivars. The Soil properties remained unaffected except available N. The available N was recorded highest under Sweetcorn followed by CPGB-4202. Thus, most of the maize cultivars were able to perform under organic farming practices with the 100 kg N equivalent dose of organic manures but the optimum potential of cultivars may be assessed under varied nitrogen and sowing time.

**Keywords:** Maize cultivars, organic farming, nutrient uptake, yield

## Introduction

Today, the Indian agriculture has transformed itself from organic cultivation system during independence to high input agriculture to meet food demand for the ever increasing human and animal population. The inadequacy of fertilizer for crop production is a constraint which is governed by exim policy of the Government. There exists a nutrient deficit of more than 10 million tonnes. The production of phosphatic fertilizers is inadequate in the country due to dependency on other countries for raw materials for fertilizer manufacture. Almost 100 percent potassic fertilizers are imported. Keeping in view these conditions farmers are ought to use other nutrient management strategies for sustainable crop production. One of these strategies is organic farming, which is a holistic production management system that promotes and enhances health of agro-ecosystem related to bio-diversity, nutrient bio-cycle and soil biological and microbial activities. It is a form of agriculture that relies on technique such as crop rotation, green manure, compost and biological pest control. Thus, while practicing organic farming one has to use composts/fertilizers and pesticides if they are considered natural (such as bone meal from animals etc). In organic farming use of synthetic petrochemical fertilizers and pesticides plant growth regulators such as hormones, antibiotic, genetically modified organism etc. is strictly limited. Long term field experiments have clearly visualized the negative impact of continuous use of chemical fertilizers on soil health (Yadav, 2003) [12]. In addition to the above, due to prohibit cost of chemical fertilizers, the majority of marginal and small farmers do not apply recommended dose of chemical fertilizers. They usually apply the indigenous sources of nutrients. Hence, there is need to adopt practices, which can improve the soil health and increase the crop yield. Efficient use of organic sources of nutrients helps in sustaining the crop production and soil health. The adoption of organic farming is, thus, important and there is further need to assess the suitability of different cultivars of crop(s) that perform better under this management practice as all of them may or may not respond equally under similar nutrient management. The organics used under organic farming includes FYM, compost, green leaf manure, vermicompost *etc*. and they contain reasonable amount of nutrients.

The synchronization of nutrient release and uptake from plant are very much required (Anderson and Ingram, 1993) [22]. Experimental findings revealed that nonetheless of slow in break down and supply rate of nutrients from the organic source, they still maintaining the good organic matter content which helps the plant to uptake nutrient for longer time (Sharma and Mitra, 1991; Vanlauwe *et al.*, 2004; Abou el-Magd *et al.*, 2005) [1, 8, 11].

Maize ‘the queen of cereals’ is one of the most potential cereals grown globally, and is the third after wheat and rice in total food grain production in the country. Maize is now widely cultivated around the world, and a greater weight of maize is produced each year than any other grain. In India, maize is the third most important crop, after rice and wheat. Karnataka, AP, Bihar, MP. UP and Rajasthan are the main maize producing states. In our country, more than 50 per cent of maize is used as animal feed (Singh *et al.*, 2003) [26]. The state of Madhya Pradesh is one of the traditional and potential maize growing states, accounting for 13 per cent of the total maize area and contributing equally to the total maize production in the country (2001-03). However, the productivity of maize in Madhya Pradesh is low if compared to that of other maize-growing states.

Today the production level of maize is ranging been 4-8 t/ha depending upon soil type, climate, cultivars, management practices etc. Hence an attempt was made in this investigation to assess the maize cultivars under organic farming with respect to their suitability for organic production.

## Material and Methods

The present study was conducted in the *kharif* season of 2014 in an on-going experiment of Network Project on Organic Farming (NPOF) at the Indian Institute of Soil Science, Bhopal.

## Study site

The study was conducted at IISS Bhopal (23˚ 18’ N, 77˚ 24’ E, 485 M above mean sea level). The location has sub - humid tropical climate with a mean annual air temperature of 25˚C and annual rainfall of 1208 mm. The soil of the experimental site is clayey in texture (*Typic Haplustert*), medium in organic C, slightly alkaline, and non-saline with low available N, medium P, and K contents. The meteorological observation recorded during the crop growth period is presented in Fig.1.

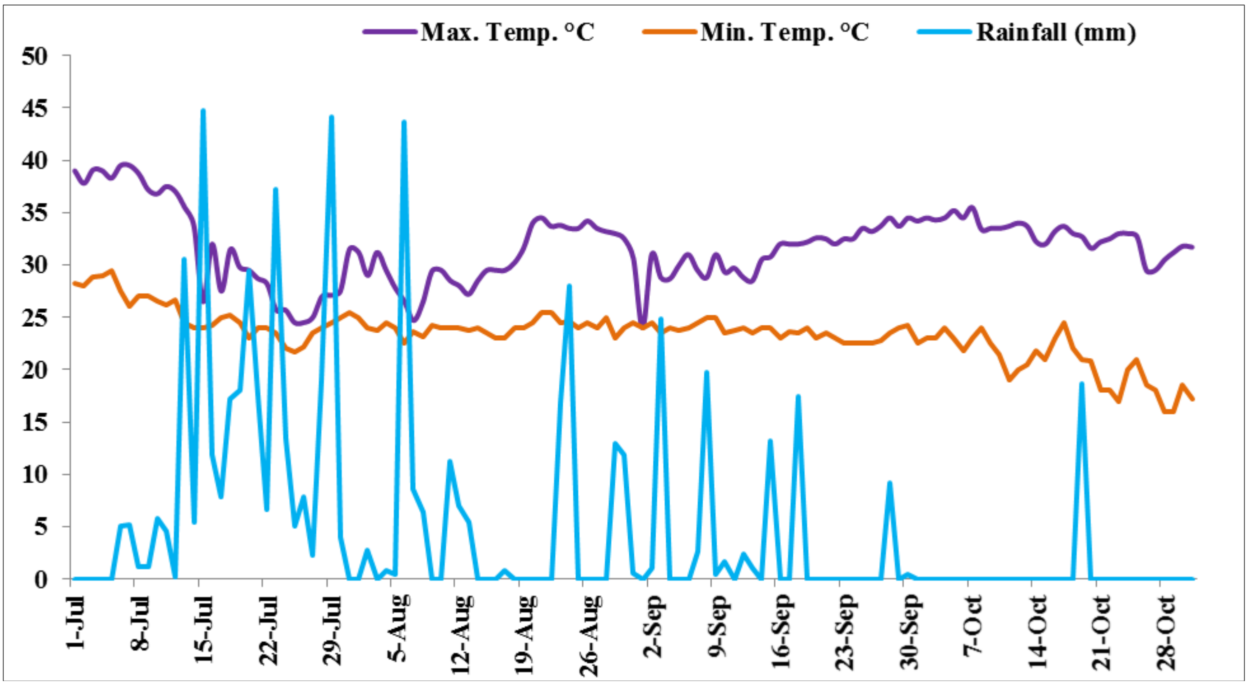


**Fig 1:** Meteorological observations during the study period

## Initial soil characteristics

The experimental soil belongs to vertisol having pH 7.85, organic carbon 0.67% and EC 0.50 dS $m^{-1}$. The available soil nitrogen, phosphorus and potassium were 154.2, 12.77 and 530.2 kg $ha^{-1}$, respectively.

## Treatments/ Cultivars

The twelve different cultivars of maize were selected and used as test crop for performance evaluation under organic farming. The basic information of cultivar and experiment is presented in Table 1.

**Table 1:** Cultivar and experiment details

| | |
|---|---|
| Cultivar (12) | Kanchan, Arawali, Sona-222, JM-8, JM-12, JM-216, Pratap-5, Pratap-6, Proagro-4412, CPBG 4202, Popcorn-1, Sweetcorn |
| Experimental design | Randomized Block Design (RBD) |
| Replications | 03 |
| Plot Size | 5×4 $m^2$ |
| Nitrogen dose | 100 kg $ha^{-1}$ |

## Field operations

All the cultivars were sown on 11th July, 2014 at a spacing of 60 cm from row to row and 25 cm from plant to plant. These were raised with similar dose of organic manures viz. cattle dung manure + vermin compost + poultry manure (1:1:1) meeting a total of 100 kg N $ha^{-1}$ applied before sowing. The details of nutrient contents in these manures are presented in Table 2. All the cultivars were grown under rainfed situation with standard package of practices for organic farming. No chemical weeding was carried out. All the cultivars were harvested on 16th October, 2014 and air dried and grain yields were recorded.

**Table 2:** Nutrient composition of the manures used in experiment

| S. No. | Compost | N (%) | P (%) | K (%) | Moisture (%) | Quantity (kg plot$^{-1}$) | Quantity (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| 1 | Cow dung manure | 0.92 | 0.54 | 1.12 | 38.8 | 9.98 | 4990 |
| 2 | Vermicompost | 1.36 | 0.68 | 1.28 | 23.4 | 5.98 | 2990 |
| 3 | Poultry manure | 2.36 | 1.42 | 1.40 | 14.0 | 3.28 | 1640 |

**Plant sampling, processing and analysis**

Plants were sampled at harvesting stages. The leaves were separated from stalks. These were first dried under shade and then in hot air oven at 80°C till constant weight. The dried samples were weighed for estimation of biomass yield and then ground and kept for nutrient analysis. The nitrogen, phosphorus and potassium content in plant parts were analyzed with procedures given below in Table 3. The total nitrogen was estimated from the separate digest by taking 0.5 g sample and digesting it in the presence of concentrated sulphuric acid and digestion mixture till a light green digest was obtained. The digest was taken to distillation assembly and 40% NaOH was added to it and the $NH_3$ gas evolved which was absorbed in boric acid containing mixed indicator. The distillate was titrated with standard $H_2SO_4$. A blank sample was also run for both the digestion procedures and the N content was calculated.

**Table 3:** Chemical analysis of plant samples

| Particulars | Method |
|---|---|
| Nitrogen content | Micro Kjeldhal method (Chapman and Pratt,1982) |
| Phosphorus content | Vanado-molybdate Yellow colour method (Kitson and Milton,1944) [24] |
| Potassium content | Di-acid digestion method by flame photometer (AOAC,1984) [17] |

For determination of total P and K in dried plant samples, 0.5 g dried sample was digested with di-acid ($HNO_3$:$HClO_4$ = 9:4) for 2-3 hours in a digestion assembly till white fumes were seen in the digest and it was clear. A blank sample was also run for both the digestion. The digested samples were diluted with water, filtered and volume was made to 100 ml. These samples were stored for determining the P and K content. The P was determined by yellow color method and potassium was determined in the digest with the help of flame photometer after suitable dilution. The content of P and K was measured against the standard curve. Measured P or K content was multiplied with dilution factor to arrive at the total P and K content in the plant parts. The nutrient uptake in plant parts was estimated by multiplying the percent nutrient content with dry biomass yield.

**Soil sampling and analysis**

At the harvest of cultivars, soil samples were collected from the surface (0-15 cm) soil. These were dried under the shade and ground to pass through 2 mm sieve and analysed for pH, electrical conductivity, and available N, P and K as per standard procedures (Table 4).

**Table 4:** Chemical analysis of soil samples

| Particulars | Method |
|---|---|
| Available nitrogen | Modified alkaline permanganate method (Subbiah and Asija, 1956) [14] |
| Available phosphorus | Olsen’s extractant colorimetric method (Olsen *et al.*, 1954) [15] |
| Available potassium | Neutral normal ammonium acetate (Toth and Prince, 1949) [27] |
| Electrical conductivity | By EC meter in1:2 soil:water suspension (Jackson, 1973) [16] |
| Soil pH | By pH meter in1:2 soil:water suspension (Jackson, 1973) [16] |
| Organic carbon | Dichromate oxidation method (Walkley and Black, 1934) [13] |

**Statistical analysis**

The data obtained with respect to yield, nutrient uptake and soil properties was subjected for statistical analysis using WASP 2.0 software developed by ICAR Coastal Agricultural Research Institute, Goa. The mean values were grouped for comparisons and the least significant differences among them were calculated at $P$<0.05 confidence level using ANOVA statistics as outlined by Gomez and Gomez (1984) [5].

**Results and Discussion**

**Grain yield and biomass**

The cultivars Proagro-4412 produced more biomass yield but statistically at par yield (3499 kg ha$^{-1}$) with Kanchan that recorded maximum grain yield of 3426 kg ha$^{-1}$. With respect to JM-8 and JM-12 were statistically at par grain yield, however, JM-216 resulted in significantly lower yield. Cultivars Arawali, Pratap-5, Pratap-6 as well as CPGB-4202 produced significantly at par maize grain yield. Popcorn-1 and Sweetcorn produced the minimum grain yield of maize (Figure 2). The total biomass production of maize cultivars ranged between 3568 kg ha$^{-1}$ (Popcorn-1) and 8003 kg ha$^{-1}$ (Proagro-4412). The second highest biomass production was recorded with Kanchan (7423 kg ha$^{-1}$) followed by JM-8. The behavior of Pratap-5 and Pratap-6 was also statistically different. The harvest index ranged between 0.42 (Pratap-6) and 0.47 (Popcorn-1).

Plants may not differentiate among the nutrients supplied through fertilizers or other organic sources; however, the adequacy of available nutrients during the crop growth may determine the productivity of a crop. The data on the performance of different cultivars under organic farming has revealed that all the cultivars could be grown successfully with the 100 kg ha$^{-1}$ N equivalent dose of organic manures through vermin compost, cow dung manure and poultry manure in 1:1:1 ratio. Significant variations in plant parameters were recorded among the cultivar with respect to grain yield and total biomass of different maize cultivars which may be attributed to the genetic makeup of these cultivars and/or limited supply of nutrients from the manures. Adekunle *et al.* (2005) [21] also reported significant variations in plant growth and yield parameters with application of cattle dung applied @ 10 t ha$^{-1}$ to cowpea in a mixed farming system.

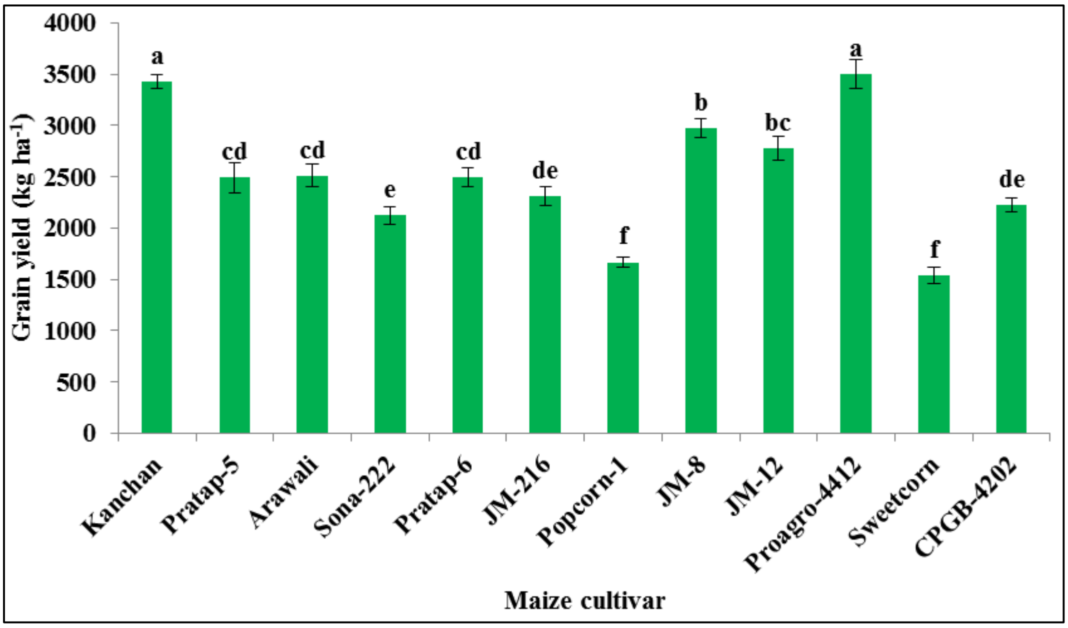


**Figure 2.** Grain yield of various maize cultivars under organic farming farming (Bar with different lower case letter are significant according to Duncun's Multiple Range Test $P<0.05$; Error bar indicates SEm±)

The plant growth parameters are genetically as well as environmentally controlled and different cultivars and hybrids have differences in these parameters. Besides environmental factors, the ability of plant to remove the soil nitrogen also influences the growth and different growth attributes of cultivars (Ehdaie and Waines, 2001) [4]. In our study, all maize cultivars differed significantly with respect to yield and total biomass. Tahir *et al.* (2008) [9] also reported difference in physiological parameters of hybrid cultivars of maize grown in similar environment in Pakistan. As far as the effect of environmental factors on plant growth parameters is concerned it could not be neglected but the selection of proper crop cultivar manages the influence of environment. These results are in accordance with the findings of Ali *et al.* (2012) [3] who also reported significant differences in plant growth parameters of different maize hybrids.

Grain yield is the combined outcome of genetic potential and environment interaction and it is the ultimate objective of all the research. The variability in genetic potential among varieties is a major component of variable yield. The variability in the yield of maize in particular is also attributed to plant density, fertilizer use, water supply, weed control, insect pest management and the selection of cultivars under a given set of environments (Tahir *et al.*, 2008) [9]. The grain yield of maize cultivars ranged between 1538 kg $ha^{-1}$ (Sweetcorn) and 3499 kg $ha^{-1}$ (Proagro-4412). It is proportional to total biomass yield. The grain yield data indicated that maize cultivars varied significantly for grain yield. Uribelarrea *et al.* (2004) [10] reported that, varieties that have been able to absorb and store nitrogen in their reproductive organs had more total biomass and grain yield due to the use of the absorbed material and more photosynthesis. McCutcheon *et al.* (2001) [6]; Olakajo and Iken (2001) [7] and Akbar *et al* (2009) [2] have also reported significant differences in grain yield among different maize cultivars grown under similar conditions.

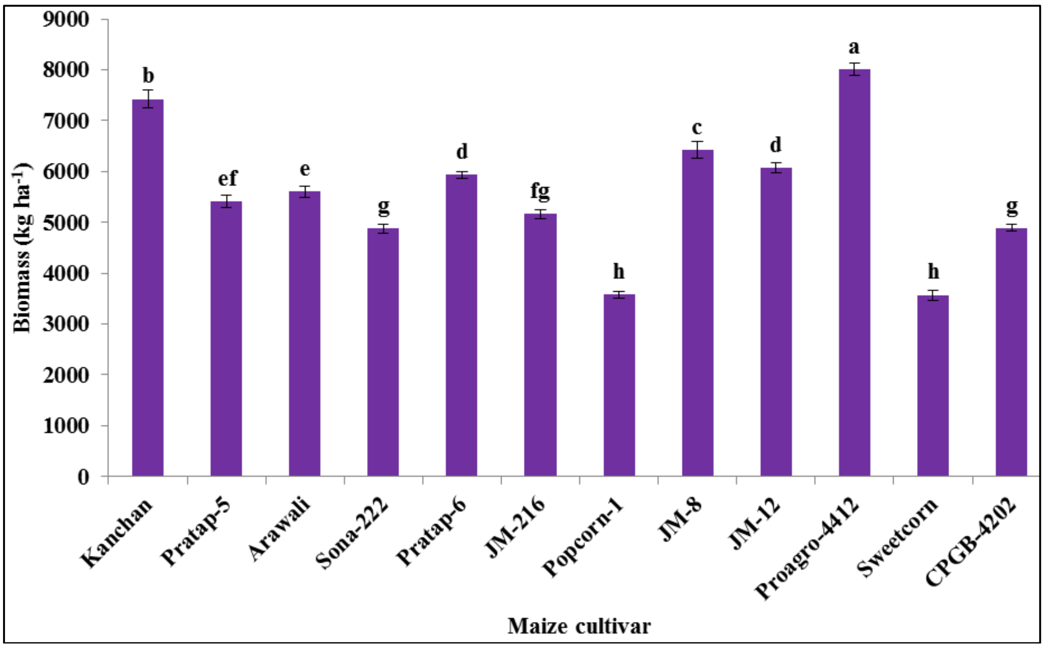


**Fig 3:** Total biomass of various maize cultivars under organic farming (Bar with different lower case letter are significant according to Duncun's Multiple Range Test $P<0.05$; Error bar indicates SEm±).

**N, P and K uptake**

The total N uptake by different maize cultivars has been presented in Figure 4. The N uptake in different maize cultivars varied between 28.1 and 61.6 kg ha$^{-1}$ under Kanchan and Sweetcorn, respectively. The cultivar Proagro-4412 recorded significantly lower N uptake than Kanchan. The cultivars JM-12, Pratap-5 and Pratap-6 were statistically at par with respect to N uptake. Similarly, the cultivars JM-216 and CPGB-4202 were also statistically at par with each other.

It is known fact that maize is one of the highly exhaustive field crop and N responsive producing higher biomass per unit of external application. Nitrogen being a structural component of proteins involved in various biological functions. The N removal and accumulation in plant parts affected by degree of root proliferation and deep penetration which in turn absorb higher amount of nutrients from the rhizosphere and supply to the crop resulting in higher dry matter production and higher nitrogen content in plant parts (Skowronska and Filipek, 2010) [29]. The leaves and grain were the main accumulation pool for N. Total N uptake was recorded by Kanchan followed by Proagro-4412 and Pratap-6. Many of the other cultivars were statistically at par with each other. The lowest N uptake by Sweetcorn and Popcorn-1 may be attributed to poor biomass yield recorded by these cultivars. The N distribution pattern within plant organs mainly dependant on the intensity of metabolism processes (Skowronska and Filipek, 2010) [29].

The differences in nitrogen uptake among different maize varieties could be due to the differences in the plant uptake ability to absorb nutrient from the soil solution (Ehdaie and Waines, 2001) [4] and which is the basic genetic character of the crops and their varieties. Also the N mobility, grain composition and dilution effects responsible for variable N uptake by varieties. Most genetic variation in N uptake due to morphological differences in root system, root length and diameter and plant dry matter production (Bohrani and Sarvestani, 2006) [28].

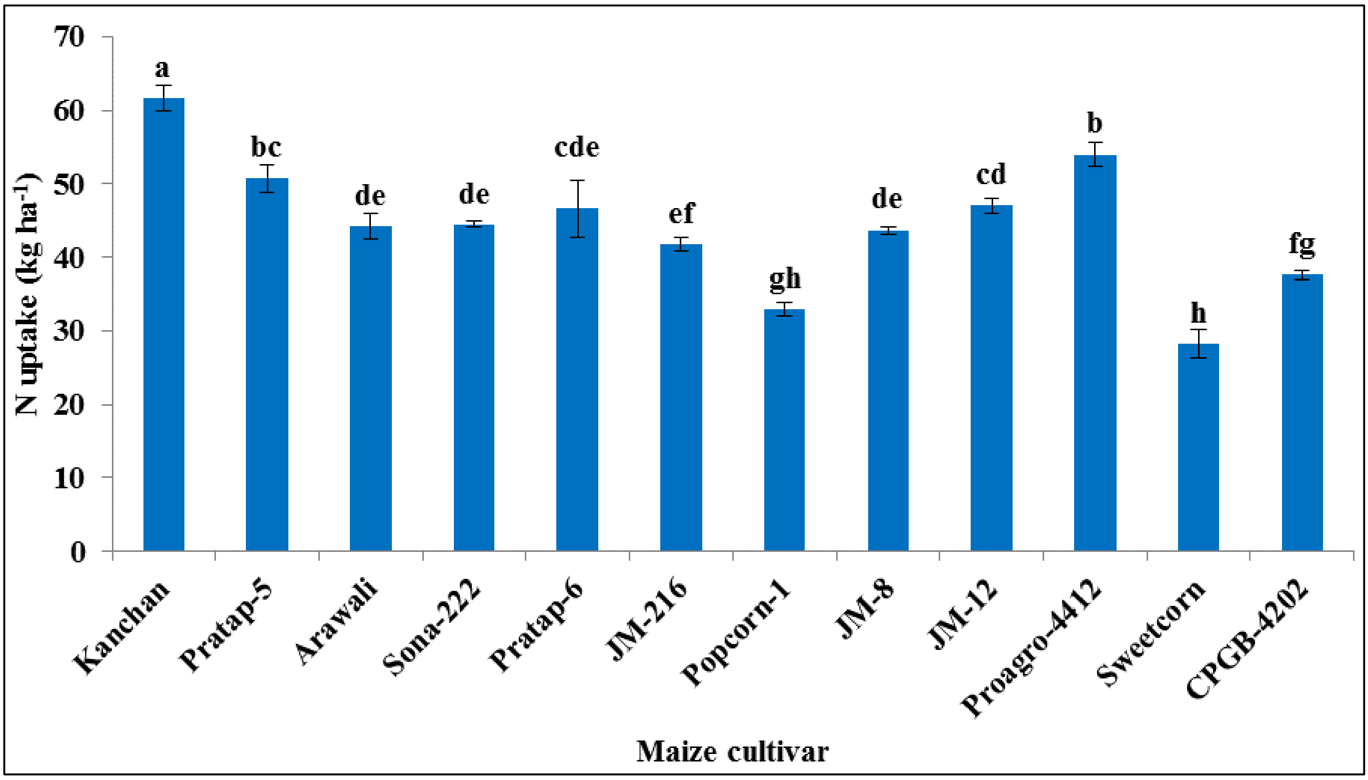


**Fig 4:** Total N uptake by various maize cultivars under organic farming (Bar with different lower case letter are significant according to Duncun's Multiple Range Test $P<0.05$; Error bar indicates SEm±).

The total P uptake by selected maize cultivars at harvest stages has been presented in Figure 5. The total P uptake by maize crop was found to vary between 7.7 kg ha$^{-1}$ in Popcorn-1 and 18.5 kg ha$^{-1}$ in Proagro-4412. Kanchan differed significantly to Proagro-4412 and registered P uptake of 15.4 kg ha$^{-1}$ that was statistically at par with JM 6, JM-12 and Pratap-5. Lowest uptake of 7.7 kg ha$^{-1}$ was registered by Popcorn-1 which was statistically at par with Sweetcorn and Pratap-6. The maize cultivar Proagro-4412 resulted in the highest total uptake of 18.5 kg ha$^{-1}$ followed by Kanchan, JM-8 and JM-216. Popcorn-1 and Sweetcorn removed minimum amount of P owing to low biomass yield. The P removal by cultivars varied considerably among varieties, the results are in good agreement with the findings of Mallarino *et al.* (2011) [20]. Phosphorus uptake is dependent on genetic makeup of varieties and growth environments. P uptake increases with increase in dry matter yields. The mean P uptakes by all the varieties were in accordance with the P uptake found by Barber and Olson (1968) [24]. Similarly, Eghball *et al.* (2003) [23] also reported that the phosphorus removal by various corn hybrids ranged between 16.6 and 35 kg ha$^{-1}$.

The total K uptake by different cultivars has been presented in Figure 6. The total K uptake ranged between 23.6 kg ha$^{-1}$ (Popcorn-1) and 58.6 kg ha-1 in Proagro-4412. The Kanchan and JM-8 removed K next to Proagro-4412. Similarly, Sweetcorn removed statistically at par K with Popcorn-1. Arawali, JM-12, Pratap-5 and CPGB-4202 were found statistically at par with respect to the total K removal.

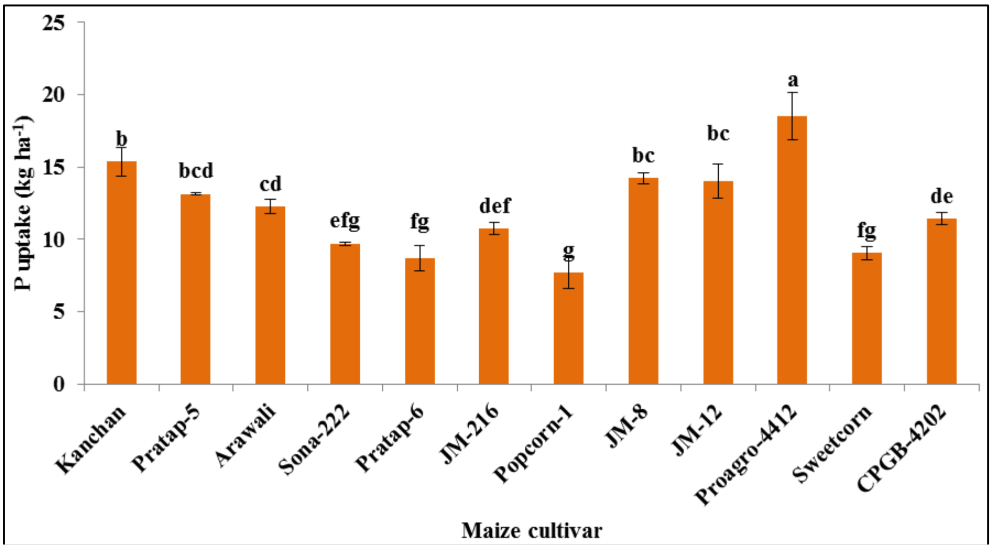


**Fig 5:** Total P uptake by various maize cultivars under organic farming (Bar with different lower case letter are significant according to Duncun's Multiple Range Test $P$<0.05; Error bar indicates SEm±).

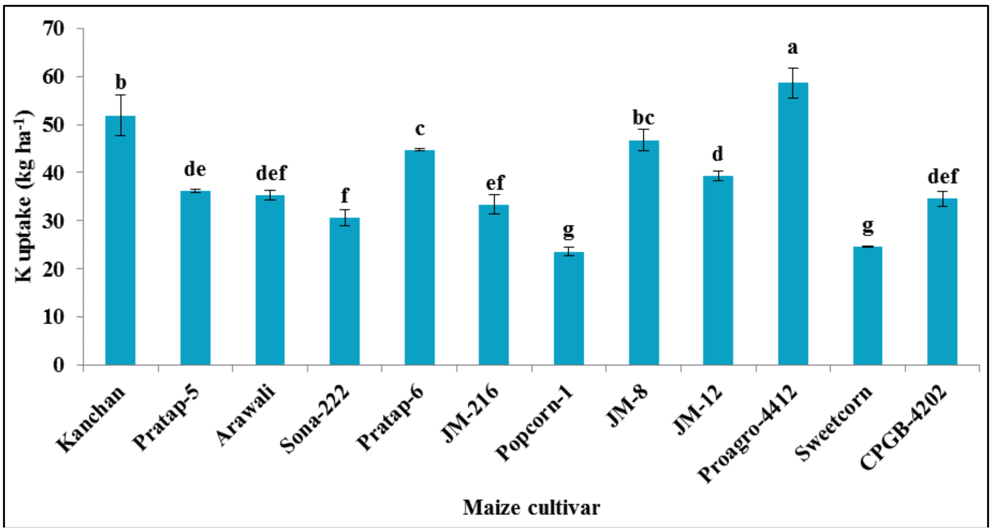


**Fig 6:** Total K uptake by various maize cultivars under organic farming (Bar with different lower case letter are significant according to Duncun's Multiple Range Test $P$<0.05; Error bar indicates SEm±).

Among different cultivars, Proagro-4412 and Kanchan were the highest in terms of total K uptake. The results are in conformity with those observed by Brij Lal and Singh (1998) [18] for Ganga Safed 2 cultivar of maize in Inceptisols of Delhi.

## Soil properties

Soil samples analysed after crop harvest revealed that there is no significant change in soil properties viz. soil pH, electrical conductivity soil available P, available K and soil organic carbon. However, there were significant difference in soil available N among different cultivars. The highest available N was recorded under Sweetcorn (291 kg ha$^{-1}$) followed by CPGB-4202. JM-12 (263 kg ha$^{-1}$) was statistically at par with Proagro-4412. Except for these four cultivars the available N was statistically at par in all the remaining 8 maize cultivars.

**Table 5:** Soil properties after harvest of maize cultivars grown under organic farming

| Variety | pH | | EC (dS m$^{-1}$) | | Soil available nutrients (kg ha$^{-1}$) | | | | | | Organic carbon (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | N | | P | | K | | | |
| Kanchan | 7.79 | a | 0.15 | a | 243 | cd | 36.0 | a | 422 | a | 0.71 | a |
| Arawali | 7.87 | a | 0.13 | a | 234 | d | 35.0 | a | 445 | a | 0.71 | a |
| Sona-222 | 7.84 | a | 0.13 | a | 232 | d | 37.7 | a | 433 | a | 0.71 | a |
| JM-8 | 7.86 | a | 0.13 | a | 226 | d | 32.7 | a | 422 | a | 0.72 | a |
| JM-12 | 7.76 | a | 0.13 | a | 263 | b | 33.7 | a | 484 | a | 0.72 | a |
| JM-216 | 7.84 | a | 0.12 | a | 240 | cd | 32.6 | a | 408 | a | 0.71 | a |
| Pratap-5 | 7.78 | a | 0.13 | a | 243 | cd | 37.0 | a | 419 | a | 0.72 | a |
| Pratap-6 | 7.84 | a | 0.12 | a | 224 | d | 34.9 | a | 423 | a | 0.72 | a |
| Proagro-4412 | 7.82 | a | 0.14 | a | 255 | bc | 36.2 | a | 475 | a | 0.71 | a |
| CPGB-4202 | 7.78 | a | 0.12 | a | 289 | a | 35.5 | a | 433 | a | 0.71 | a |
| Popcorn-1 | 7.79 | a | 0.12 | a | 228 | d | 32.7 | a | 403 | a | 0.71 | a |
| Sweetcorn | 7.87 | a | 0.12 | a | 291 | a | 33.3 | a | 409 | a | 0.71 | a |

*Columns with different lower case letter are significant according to Duncun's Multiple Range Test $P$<0.05; Error bar indicates SEm±.

## Conclusions
The cultivar Proagro-4412 and Kanchan resulted in higher yield to the tune of 3.4 to 3.5 t $ha^{-1}$. However Popcorn-1 and Sweetcorn were the least responsive cultivars under organic farming. Cultivars JM-12, JM-8 also resulted higher yield those were significantly lower than Kanchan and Proagro-4412. Kanchan removed maximum nitrogen from soil followed by Proagro-4412, Pratap-5 and JM-12 cultivars. The range of N uptake by cultivars is relatively lower as it varied between 28.1 and 61.6 kg $ha^{-1}$. It indicates that the supply of N from organic manure may not have met the crop demand of most of the cultivars. The P removal was higher under Proagro-4412 and Kanchan cultivars and the lowest removal was under Popcorn-1 and Sweetcorn. Total K removal by different cultivars varied between 23.6 and 58.6 kg $ha^{-1}$. Proagro-4412 and Kanchan removed maximum K compared to other cultivars. Soil properties remained unaffected except available N. The available N was recorded highest under Sweetcorn followed by CPGB-4202. Thus, most of the maize cultivars were able to perform under organic farming practices with the 100 kg N equivalent dose of organic manures. However, the optimum potential of cultivars may be assessed under varied nitrogen and sowing time.

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