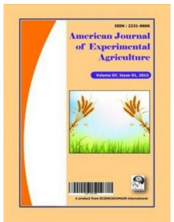

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Influence of Integrated Nutrient Management on Growth and Yield of Sweet Corn (*Zea mays* L. *saccharata*) under Temperate Conditions of Kashmir Valley

Shahid Rasool[1*], R. H. Kanth[2], Shabana Hamid[3], W. Raja[2], B. A. Alie[2] and Z. A. Dar[4]

[1]CSIR- Indian Institute of Integrative Medicine, Srinagar, Kashmir, India.
[2]Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India.
[3]Department of Agriculture, J&K Government, Kashmir, India.
[4]Division of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India.

Authors' contributions

This research work was carried out in collaboration between all authors. Authors SR and RHK designed the study, wrote the protocol and wrote the first draft of the manuscript. Author BAA reviewed the experimental design and all drafts of the manuscript. Authors SR and SH managed the analyses of the experiment. Authors ZAD and WR performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

The growth and yield response of sweet maize (*Zea mays* (L.) saccharata) to varying levels of organic and inorganic fertilizers during the growing seasons of *kharif* 2010 and 2011 was studied under temperate conditions of Kashmir Valley. Twelve treatments comprising of sole and combination of organic and inorganic fertilizers were laid in a randomized block design with three replications. The results revealed that application of T_{10} [75% (NPK) + FYM (4.5 t/ha) + Biofertilizer (*Azotobacter* + Phosphate solubilizing bacteria (PSB))] significantly increased the number of days

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**Corresponding author: E-mail: msrasool@iiim.ac.in;*

taken to tasseling, silking and milky stages and various other growth characters viz., plant height, leaf area index and dry matter accumulation at 15 days interval from sowing up to harvest and crop growth rate and relative growth rate at 7 days interval from 15 DAS up to harvest whereas, the lowest values of these parameters were recorded in unfertilized control. The treatment T_{10}[75 % (NPK) + FYM (4.5 t/ha) + Biofertilizer (*Azotobacter* + Phosphate solubilizing bacteria (PSB))] proved to be significantly superior to rest of the treatments including unfertilized control in increasing cob yield with and without husk, fodder yield and green biomass yield during both years of experimentation, however, ratio of cob to fodder yield during 2011 and 2012 were recorded highest in treatment T_3 [FYM (18 t ha^{-1})] and T_2 [Recommended NPK kg ha^{-1} (90:60:40)], respectively, whereas unfertilized control recorded the lowest ratio of cob to fodder yield.

Keywords: Sweet maize; organic fertilizer; inorganic fertilizers; growth; yield.

1. INTRODUCTION

Sweet corn is one of the most popular vegetables in the USA, Canada and Australia. It is becoming popular in India and other Asian countries. Sweet corn differs from other corns (field maize, pop corn and ornamental) because the kernels have a high sugar content in the milk on early dough stage. It is consumed in the immature stage of the crop. The kernels of sweet corn taste much sweeter than normal corn, especially at 25-30% maturity. The sweet corn industry is expanding because of increasing domestic consumption, export development and import replacement. It is an attractive crop for producers to grow because the plant grows quickly and is considered a valuable rotational crop and farming operation can be mechanized. Planting usually commences in spring when soil temperature reaches above 12°C. In warmer regions with longer growing season allows two crops to be planted each year, however taking the major constraints of shorter growing period (April to September) together with cold stress at early and late stages of crop growth restricts it to mono-cropping under temperate conditions.

The potential of the sweet maize crop is not being exploited satisfactorily due to many constraints among which inappropriate nutrient supply ranks first. Others are pest problems at maturity, low fertility status of the soils and the high cost of the scarce inorganic fertilizers with their potential polluting effects on the environment following continuous usage. Soils of the agro-ecology are generally low in organic matter as a result of the rapid mineralization and the fact that very little organic matter is added to the soil during and after cropping [1]. The need to use renewable forms of energy has rekindled interest in the use of organic manures such as cow dungs, poultry droppings and crop residues as alternatives for inorganic fertilizer worldwide. Application of organic manures plays a direct role in plant growth as a source of all the necessary major and minor nutrients in available forms during mineralization which improves both the physical and biological properties of the soil [2]. Nutrients contained in organic manures are released more slowly and are stored for longer periods in the soil, thereby ensuring a long residual effect [3]. To meet crop's nutrient needs, organic manures are however, required in rather large quantities which now make for a strong advocacy for fortifying these manures with inorganic fertilizers. A positive interaction has been shown to exist between the combination of organic manures and urea as N source [4,5]. [5] reported that the combined use of poultry manure and urea gave the best performance for sweet maize amongst all treatments. Manures application has also been reported to increase the N and exchangeable cations levels in the soil [6]. Keeping this in view the present study was undertaken with an objective to evaluate the performance of sweet maize under the combined use of organic and inorganic fertilizers.

2. MATERIALS AND METHODS

A field experiment was conducted for two consecutive years (*kharif* 2011 and 2012) at the Experimental Farm of the Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir that lies between 34° 0.8 • N latitude and 74° 83 • E longitude at an altitude of 1587 meters above mean sea level. The experimental site was well drained and had uniform topography. The experiment was laid out in a Randomized Block Design with three replications and comprising of 12 treatments/ the treatment details are given in Table 1.

The chemical fertilizers Urea, DAP and MOP were used as source of nitrogen, phosphorus and potassium, respectively, FYM and vermicompost were used as source of nitrogen, phosphorus, potassium and micro-elements also in the form of organic manure. The microbial culture of *Azotobacter* and PSB were used as bio-fertilizers. Farmyard manure (FYM) and vermicompost were applied to the respective plots, as per the layout plan, and mixed thoroughly with the soil. Half of the nitrogen was applied as basal at the time of sowing and the remaining half of nitrogen in two splits each at knee high and tassel emergence stage in the respective plots at the rates as per layout plan. Phosphorus and potassium were applied, at the rates as per layout plan to the respective plots at the time of sowing. *Azotobacter* and PSB were used as a seed treatment (50 g kg^{-1} seed) to the respective plots.

The data were recorded from five randomly selected plants which were tagged from penultimate rows of each plot and the average for every parameter was worked out. Days taken to different physiological stages were recorded at various growth stages i.e. knee high, tasseling, silking and milking stages. Plant height (cm), leaf area index and dry matter accumulation (q ha^{-1}) were recorded at 15 days interval from the date of sowing. Green cob yield with and without husk (q ha^{-1}), green fodder yield (q ha^{-1}), biomass yield (q ha^{-1}) and ratio of cob to fodder yield were recorded from 5 cobs taken randomly from each net plot and then converted to q ha^{-1}. Crop growth rate (g $g^{-1}day^{-1}$) and relative growth rate (g $g^{-1}day^{-1}$) were calculated at 7 days interval according to the formula of [7,8], respectively.

$$\text{Crop growth rate (g g}^{-1}\text{day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

W_1 and W_2 = Dry matter production per plant (g) at time t_1 and t_2, respectively.

$$\text{Relative growth rate (g g}^{-1}\text{day}^{-1}) = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

W_1 = Dry weight of plant at time t_1, W_2 = Dry weight of plant at time t_2

The data obtained in respect of various observations were statistically analyzed by the method described by [9]. The significance of "F" and "t" was tested at 5 % level of significance. The critical difference was determined when "F" test was significant.

3. RESULTS AND DISCUSSION

The present investigation indicated that application of T_{10} significantly increased the number of days taken to tasseling, silking and milky stages than other treatments but remained at par with T_2, T_8, T_9, T_{11} and T_{12} during 2011 and 2012, however, significantly lowest number of days for the crop to reach these stages was recorded in unfertilized control (Fig. 1 and 2). These results are in accordance with the results obtained by [10]. With the release and availability of sufficient nitrogen supply from the combined nutrition of inorganic and organic nature the advancement of the crop enhanced because of mere fact that nitrogen is a part of chlorophyll and is involved in cell division and enlongation. The nitrogen is also known to delay the reproductive period of the crop which is evident from the present findings i.e. increased number of days to tasseling, silking and milky stage.

Plant height is an important growth index to study the accumulation of dry matter by the plant and is very important to monitor the overall canopy architecture and also govern the orientation of the leaves that further govern the photosynthetic efficiency of a plant to utilize the natural resources. It was found that the periodic plant height of the crop went on increasing upto harvest and the magnitude of increase was more than double from 15-30 and 30-45 DAS irrespective of treatments. The results revealed that the plant height recorded with T_{10} from 60 DAS, 75 DAS and harvest was significantly higher than unfertilized control, T_3, T_4 and T_5 inoculation but at par with rest of the treatments during 2011 and 2012 (Figs. 3 and 4), however, at 15 DAS T_{10} recorded significantly higher plant height than other treatments. Significantly lowest periodic plant height was recorded under the treatment of unfertilized control. Similar results were also obtained by [11-13]. Significant effect on the increase on the plant height in sweet corn with the application of NPK may be attributed to the fact that nitrogen being an essential constituent of plant tissue favours rapid cell division and its enlargement, which together with the adequate quantity of phosphorus and potassium helps in the rapid cell division and better development of the cell size. Further, the beneficial effect of FYM may be attributed to the fact that it supplied available plant nutrients and also had solubilizing effect on fixed forms of nutrients especially phosphorus in soil [14].

Leaf area index is of paramount importance in all the crop plants, because optimum leaf area is required for maximum light interception which results for higher photosynthesis. Periodic leaf area index also increased significantly with application of T_{10} over other treatment tested during two years of study (Figs. 5 and 6). [11,15,16] also reported increased leaf area index by combined application of organic and inorganic fertilizers. Nitrogen is an essential constituent of proteins, enzymes and chlorophyll and has been observed to influence the leaf growth and its expansion, resulting in increased leaf area index. Availability of adequate phosphorus in plant results in proper leaf expansion, increase in leaf surface area and number of leaves and results in better efficiency of chlorophyll during photosynthesis and this overall improvement gets translocated into better growth of the plant. Availability of adequate quantity of potassium is essential for the better crop growth and improves the source sink relationship that helps in harvesting higher crop yield. Potassium is a cofactor of numerous enzymes and basically helps in the translocation mechanism and it improves the mobility and utilization of other elements. Besides application of FYM and biofertilizer, apart from improving soil physico-chemical and biological properties of soil releases adequate quantities of nitrogen and phosphosrus to boost up the growth of the crop thereby increasing leaf area index. Moreover, leaf area index values were highest at 75 DAS, the period coinciding silking stage and thereafter declined upto harvest. The decline in leaf area index after silking could be attributed to leaf senescence due to shading of lower leaves.

Dry matter accumulation is another important character to express the growth and metabolic efficiency of the plant, which ultimately influence the yield. Perusal of the data revealed that irrespective of treatments dry matter production went on increasing with the advancement in the age of crop upto harvest and the magnitude of increase was more than double from 15 to 30 DAS and 30 to 45 DAS. At 15, 30, 45 and 60 DAS the dry matter production recorded under treatment T(10) was significantly higher than other treatments but was at par with T_2, T_{11} and T_{12} during 2011 and 2012 (Figs. 7 and 8). However, at 75 DAS and harvest the dry matter production recorded with treatment T_{10} was significantly higher than unfertilized control and at par with rest of the treatments during two years of experimentation. The study also revealed that significantly lowest periodic dry matter was observed under unfertilized control. Similar findings were also been reported by [17-19]. The increase in periodic dry matter accumulation with application of integrated fertilizer management may be attributed to increase in plant height and leaf area index resulting thereby in better light interception by crop which accumulated more photosynthates and thus produced more dry matter. Further, FYM and biofertilizer supplied the nutrients in balanced proportion and improved the physical characters, which might have increased the availability of nutrients particularly nitrogen and phosphorus.

The results obtained in Figs. 9 and 10 revealed that application of T_{10} recorded significantly higher crop growth rate than various treatments and being generally at par with T_2, T_{11} and T_{12}, however, trend of significance recorded with T_{10} over other treatment didn't show similar pattern at all intervals of measurement, but varied from one interval to another. Similar trend was also noticed for relative growth rate at different growth intervals (Figs. 11 and 12). [20] reported that application of NPK along with FYM significantly increased crop growth rate and NAR of maize crop over control. These results are in agreement with those of [21]. The crop growth rate and relative growth rate, in general, indicate the amount of increase in dry matter over existing dry matter per unit time. The higher CGR and RGR obtained during the study under the above treatment is the reflection of accumulation of dry matter at the respective periods.

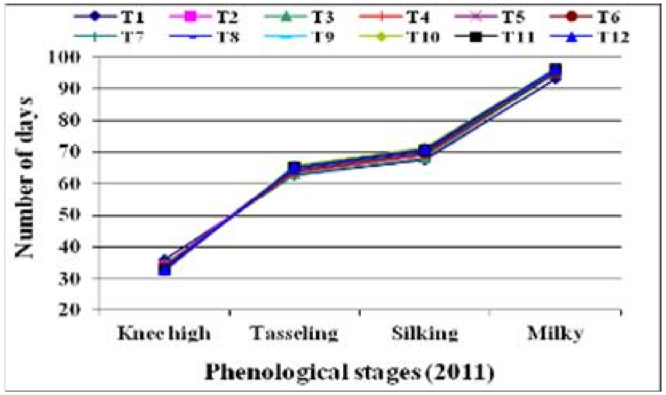
Yield is the net result of various agronomic inputs influencing growth and yield attributing characters during the life cycle of the crop. The efficiency of different factors is judged mainly by their contribution towards economic yield. The treatment T_{10} proved to be significantly superior to rest of the treatments including unfertilized control in increasing the cob yield with and without husk during both years of experimentation and pooled data over years (Table 2). The yield superiority of T_{10} over unfertilized control with regard to cob yield with husk was to the tune of 107.64, 129.96 and 119.18 per cent and with regard to cob yield without husk the increase in yield was to the tune of 99.86, 121.63 and 111.10 per cent during 2011 and 2012, respectively. Further, significantly higher green fodder and biomass yield of sweet corn were also obtained with application of T_{10} during 2011 and 2012 (Table 3). The treatments T_3 and T_2 recorded the highest cob to fodder ratio of 1:1.50 and 1:1.32 recorded the highest cob to fodder ratio during 2011 and 2012, respectively. Among the 12 treatments the lowest ratio of cob to fodder yield was observed in unfertilized control during both years of study as well as pooled data over years. Higher yields of sweet corn obtained with the application of integrated nutrients was mainly due to their positive effect on various yield contributing characters like cob length, number of cobs per plant, number of grains per cob, length and diameter of cob etc. Earlier [15,22-24 and 25] also found significant and consistent increase in cob and fodder yield with combined application of organic and mineral fertilizers. Concomitant release of nitrogen at most critical stages of their need is a key to ensure higher yields. In the present study, application of FYM and biofertilizer alongwith 75% NPK resulted in maximum yield that establishes the fact of synchrony between availability of nitrogen at critical stages of crop as well as other benefits derived from FYM. Further, application of FYM adds and exploits the fixed nutrients of soil in available form and regulates its supply to the crop through mineralization and prevents them from leaching and other losses [26]. Therefore, this study clearly revealed the importance of both inorganic and organic nutrients for enhancing the productivity of sweet corn. Increase in fodder yield with application of T_{10} could be attributed to significant improvement in plant height and dry matter accumulation of sweet corn. Increase in fodder yield with integrated nutrient management has also been reported by [20,27,28]. The results of many trails including those of long term manorial experiments conducted at different locations in India have also revealed that combined application of mineral fertilizers and organic manures is an appropriate method to achieve yields. The biomass yield is a function of cob and fodder yield, representing vegetative and reproductive growth of the crop. The results are in agreement with those of [29,30].

Table 1. Treatment details

Treatments		Details
T_1	:	Control
T_2	:	Recommended NPK kg ha^{-1} (90:60:40)
T_3	:	FYM (18 t ha^{-1})
T_4	:	Vermicompost (3.6 t ha^{-1})
T_5	:	Biofertilizer (*Azotobacter* + Phosphate solubilizing bacteria (PSB))
T_6	:	75 % (NPK) + FYM (4.5 t ha^{-1})
T_7	:	75 % (NPK) + Vermicompost (0.9 t ha^{-1})
T_8	:	75 % (NPK) + Biofertilizer
T_9	:	75 % (NPK) + FYM (2.25 t ha^{-1}) + Vermicompost (0.45 t ha^{-1})
T_{10}	:	75 % (NPK) + FYM (4.5 t/ha) + Biofertilizer (*Azotobacter* + Phosphate solubilizing bacteria (PSB))
T_{11}	:	75 % (NPK) + Vermicompost (0.9 t/ha) + Biofertilizer (*Azotobacter* + Phosphate solubilizing bacteria (PSB))
T_{12}	:	75 % (NPK) + FYM (2.25 t/ha) + Vermicompost (0.45 t/ha) + Biofertilizer (*Azotobacter* + Phosphate solubilizing bacteria (PSB))

Table 2. Effect of integrated nutrient management on green cob yield with and without husk (q ha^{-1}) of sweet corn

Treatments	Cob yield with husk			Cob yield without husk		
	2011	2012	Mean	2011	2012	Mean
T_1	167.42	161.74	164.58	126.17	121.38	123.77
T_2	261.94	286.08	273.89	188.80	206.42	197.52
T_3	249.47	314.91	281.43	185.45	228.66	206.57
T_4	260.68	288.88	275.55	191.20	210.26	201.30
T_5	210.60	226.07	219.08	159.01	172.56	166.34
T_6	277.67	295.08	287.24	202.42	214.46	209.08
T_7	276.10	281.33	278.72	200.10	204.45	202.28
T_8	250.56	277.95	264.12	182.43	201.80	192.02
T_9	273.93	301.45	287.55	199.50	219.97	209.63
T_{10}	347.63	371.94	360.72	252.17	269.02	261.28
T_{11}	287.25	320.82	303.81	210.88	234.52	222.55
T_{12}	301.65	333.48	317.38	221.57	244.53	232.92
SEm±	3.187	3.455	3.343	3.766	4.075	4.017
CD ($p \le 0.05$)	9.41	10.20	9.87	11.12	12.03	11.86



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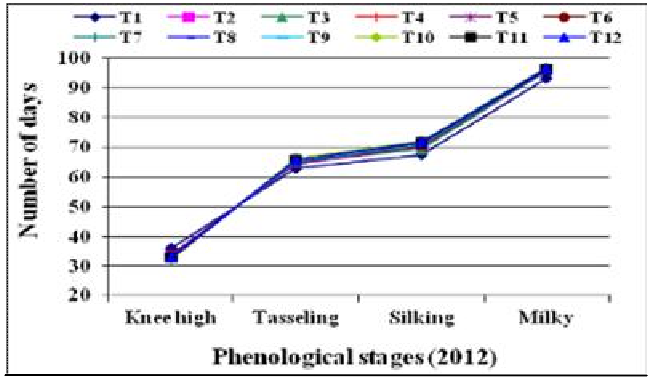
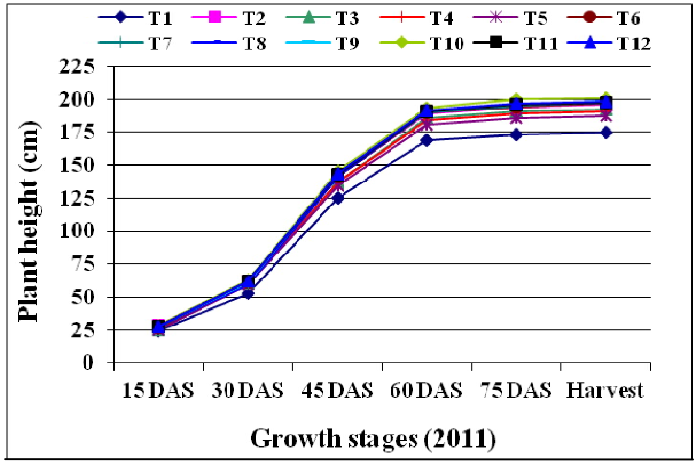


Fig. 2



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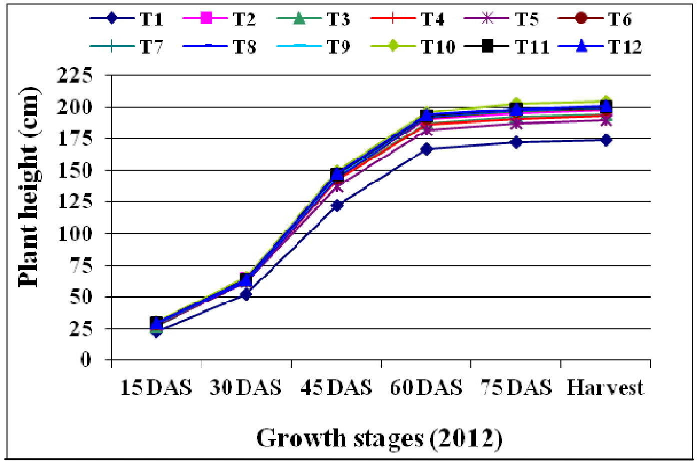

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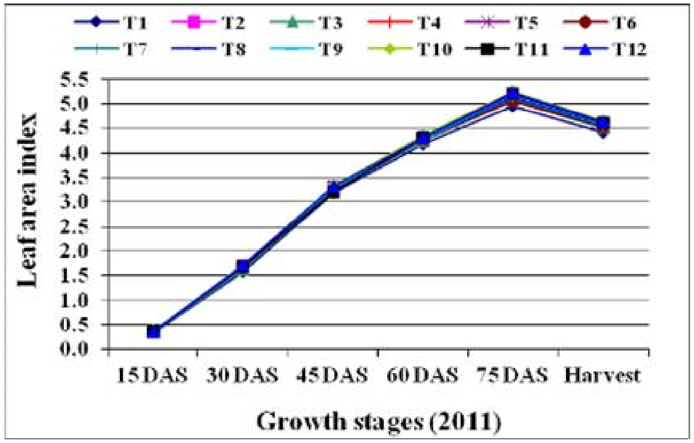

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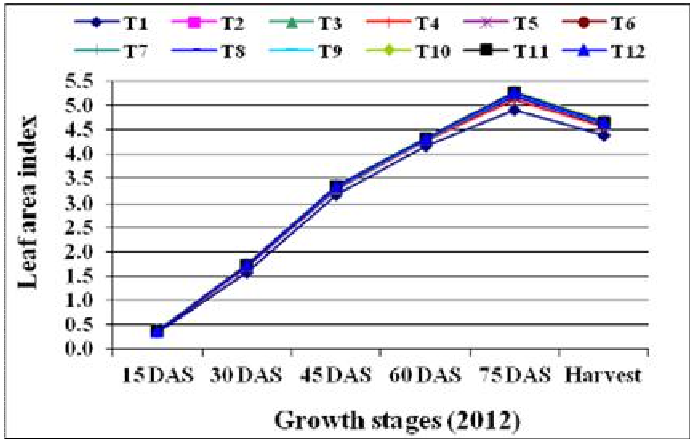

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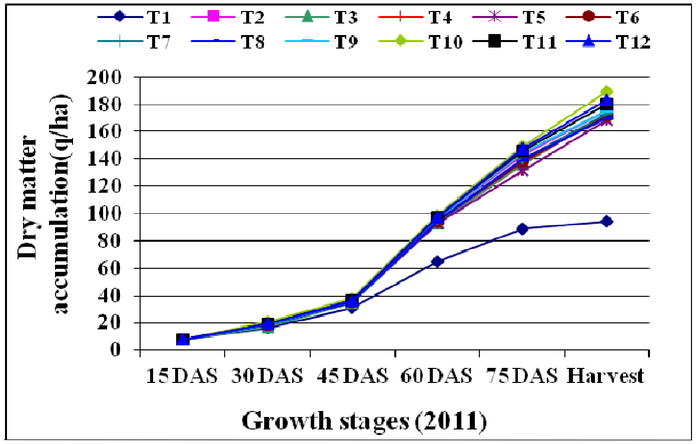

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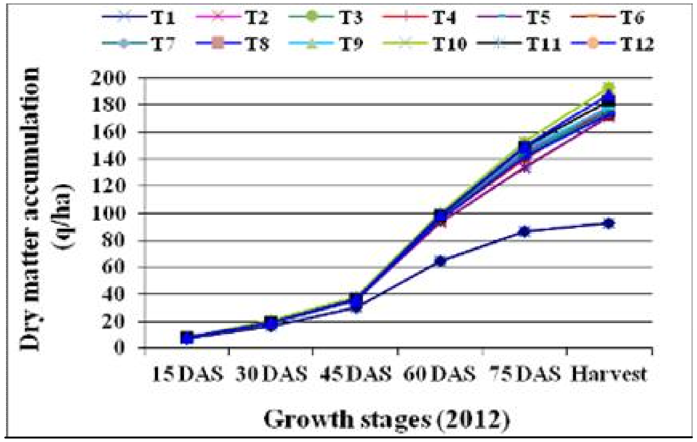

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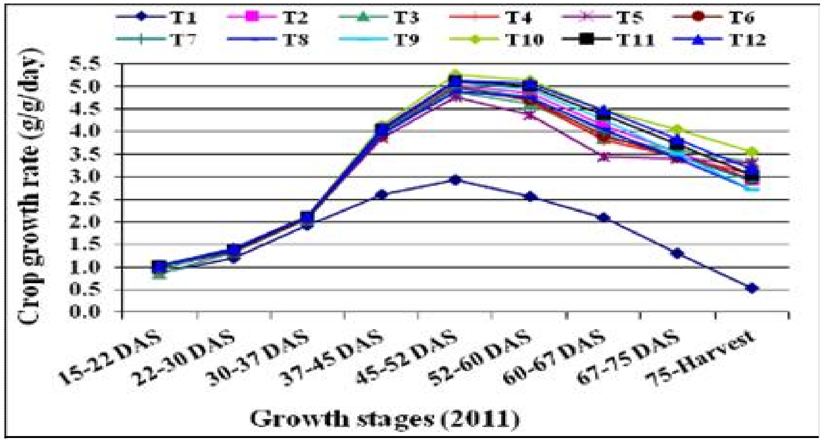


Fig. 9

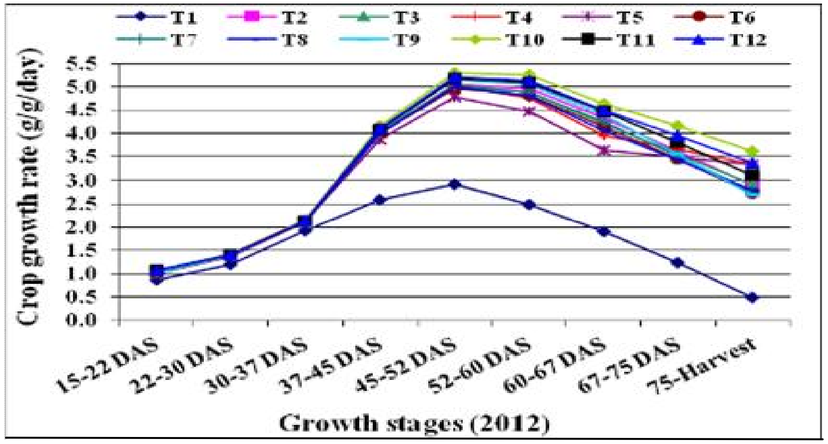
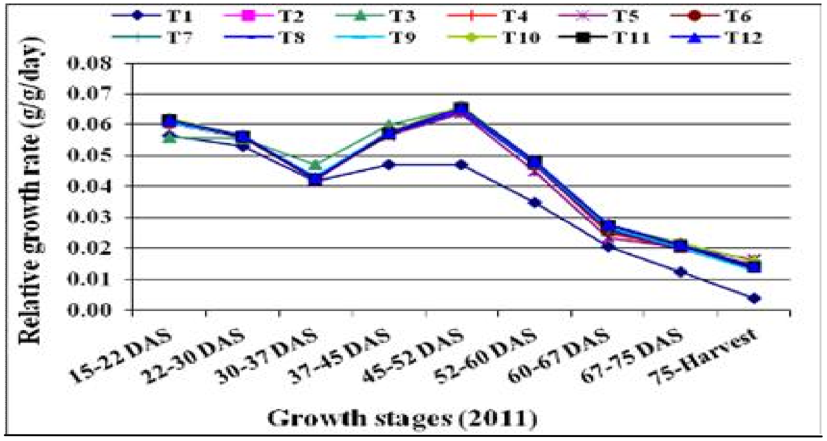


Fig. 10



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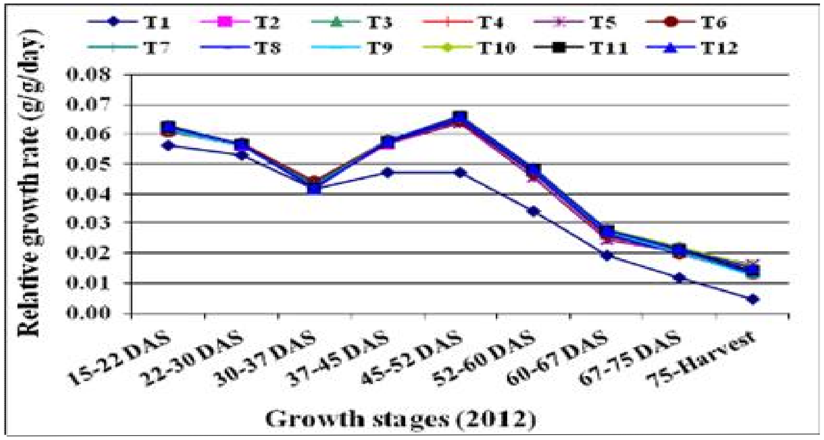

Fig. 12

Fig. 1-12. Growth parameters of sweet corn (*Zea mays* var. *saccharata*) as affected by integrated nutrient management

Table 3. Effect of integrated nutrient management on fodder yield (q ha^{-1}), green biomass yield (q ha^{-1}) and ratio of green cob and biomass yield of sweet corn

Treatments	Fodder yield			Green biomass yield			Ratio of cob to fodder yield		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
T_1	187.98	182.52	185.25	355.40	344.26	349.83	1:1.12	1:1.13	1:1.13
T_2	367.70	378.09	372.90	629.64	664.17	646.79	1:1.40	1:1.32	1:1.36
T_3	374.87	389.69	382.28	624.34	704.60	663.71	1:1.50	1:1.24	1:1.36
T_4	354.03	363.65	358.84	614.71	652.53	634.39	1:1.36	1:1.26	1:1.30
T_5	273.53	295.45	284.49	484.13	521.52	503.57	1:1.30	1:1.31	1:1.30
T_6	351.40	357.79	354.60	629.07	652.87	641.84	1:1.27	1:1.21	1:1.23
T_7	358.46	354.15	356.30	634.56	635.48	635.02	1:1.30	1:1.26	1:1.28
T_8	339.75	357.02	348.39	590.31	634.97	612.51	1:1.36	1:1.28	1:1.32
T_9	382.05	390.98	386.51	655.98	692.43	674.06	1:1.39	1:1.30	1:1.34
T_{10}	406.01	410.27	408.14	753.64	782.21	768.86	1:1.17	1:1.10	1:1.13
T_{11}	387.99	390.96	389.47	675.24	711.78	693.28	1:1.35	1:1.22	1:1.28
T_{12}	388.65	391.76	390.20	690.30	725.24	707.58	1:1.29	1;1.17	1:1.23
SEm±	5.179	5.259	5.215	12.281	13.924	13.385	-	-	-
CD ($p \leq 0.05$)	15.29	15.52	15.43	36.26	41.11	39.52	-	-	-

4. CONCLUSION

Two year investigations on "Effect of integrated nutrient management on growth and yield of sweet corn (*Zea mays* var. *saccharata*) under temperate conditions of Kashmir" revealed that application of T_{10} being at par with T_9 and T_{11} proved significantly superior in terms of cob yield with and without husk, yield attributes and growth parameters. In view of this, it may be concluded that for obtaining maximum cob and fodder yield in sweet corn, it needs to be fertilized with T_{10}. However, such studies require more critical testing at various locations over a longer period before final recommendations are made.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Lal R, Greenland DJ. Effects of organic amendments in soil physical properties and crop production in the tropics. Lal R, Greenland DJ. (eds). J. Wiley and Sons New York; 1979.
2. Abou El-Magd MA, El-Bassiong M, Fawzy ZF. Effect of organic manure with or without chemical fertilizers on growth, yield and quality of some varieties of broccoli plants. Journal of Applied Science Research. 2006;2(10):791-798.
3. Sharma AR, Mittra BN. Effect of different rates of application of organic and nitrogen fertilizer in a rice-based cropping system. Journal of Agricultural Science (Camb), 1991;117:313-318.
4. Bocchi S, Tano F. Effect of cattle manure and components of pig slurry on maize growth and production. European Journal of Agronomy. 1994;3:235-41.
5. Khaliq T, Mahmmod T, Kamel J, Masood A. Effectiveness of farmyard manure, poultry manure and nitrogen for corn (*Zea mays* L.) productivity. International Journal of Agriculture and Biology. 2004;6(2):260-263.
6. Boateng SA, Zickermann J, Kornaharens M. Effect of poultry manure on growth and yield of maize. West Africa Journal of Applied Ecology. 2006;9:1-11.
7. Redford PT. Growth analysis formulae-Their use and abuse. Crop Science. 1967;7:171-175.
8. Blackman VH. The compound interest law and plant growth. Annals of Botany. 1919;33:353-360.

9. Cochran WG, Cox GM. Experimental Designs. 2nd Ed. Johan Wiley and Sons Inc. New York; 1967.
10. Sharma MP, Gupta JP. Effect of organic materials on grain yield and soil properties of maize-wheat cropping system. Indian Journal of Agricultural Sciences. 1988;68(11):715-717.
11. Pathak SK, Singh SB, Singh SN. Effect of integrated nutrient management on growth, yield and economics in maize-wheat cropping system. Indian Journal of Agronomy. 2002;47(3):325-332.
12. Paradar VK. Development of integrated nutrient management system through organic sources to enhance productivity of maize based cropping under rainfed ecosystem at Chhindwara. 48th Annual Progress Report, All India Coordinated Maize Improvement Project, Directorate of Maize Research, Pusa Campus, New Delhi. 2005;48:77.
13. Singh H, Singh P, Sumeriya HK. Effect of fertility level on fodder yield and HCN content of sorghum (*Sorghum bicolor* L. Moench) genotypes. International Journal of Tropical Agriculture. 2008;26:417-420.
14. Ganai BA, Singh CM. Effect of FYM applied to rice-wheat rotation on physiochemical properties of soil. Indian Journal of Agronomy. 1988;33(3):327-329.
15. Afifi MH, Manal FM, Gomaa AM. Effect of biofertilizer under different levels of chemical fertilizers on maize (*Zea mays* L). Annals of Agricultural Science Moshtonor. 2003;41:1411–1420.
16. Kumar A, Thakur KS, Sharma S. Integrated nutrient management in maize (*Zea mays*) - gobhi sarson (*Brassica napus* ssp *oleifera* var. *annua*) cropping system under rainfed condition. Indian Journal of Agronomy. 2005;50:274-277.
17. Amujoyegbe BJ, Opabode JT, Olayinka A. Effect of organic and inorganic fertilizer on yield and chlorophyll content of maize (*Zea mays* L.) and sorghum (*Sorghum bicolour* (L.) Moench). African Journal of Biotechnology. 2007;16:1869-1873.
18. Singh RK, Singh SK, Singh LB. Integrated nitrogen management in wheat (*Triticum aestivum*). Indian Journal of Agronomy. 2007;53:124-126.
19. Kumar A, Dhar S. Evaluation of organic and inorganic sources of nutrients in maize (*Zea mays* L.) and their residual effect on wheat (*Triticum aestivum*) under different fertility levels. Indian Journal of Agricultural Sciences. 2010;80:364-371.
20. Singh G, Marwaha TS, Kumar D. Effect of resource conserving techniques on soil microbiological parameters under long term maize (*Zea mays* L.) – wheat (*Triticum aestivum* L.) crop rotation. Indian Journal of Agricultural Sciences. 2009;79:94-100.
21. Verma A, Nepalia V, Kanthaliya PC. Effect of nutrient supply on growth, yield and nutrient uptake by maize (*Zea mays* L.) - wheat (*Triticum aestivum* L.) cropping system. Indian Journal of Agronomy. 2006;51:3-6.
22. Kumar A, Thakur SK. Effect of integrated nutrient management on promising composite maize varieties under rainfed mid-hill conditions of Himachal Pradesh. Indian Journal of Agricultural Sciences. 2004;74(1):40-42.
23. Anonymous. 47thAnnual Progress Report, All India Coordinated Maize Improvement Project, Directorate of Maize Research, Pusa Campus, New Delhi. 2004;47:75.
24. Anonymous. 49th Annual Progress Report, 2005-2006. All India Coordinated Maize Improvement Project, Directorate of Maize Research, Pusa Campus, New Delhi. 2006;49:76.
25. Dadarwal RS, Jain NK, Singh D. Integrated nutrient management in baby corn (*Zea mays* L.). Indian Journal of Agricultural Sciences. 2009;79:1023-1025.
26. Singh GR, Choudhary KK, Chaure NK, Pandya KS. Effect of seed bacterization and nitrogen level on soil properties, yield parameters and economics of sunflower. Indian Journal of Agricultural Sciences. 1996;66(4):250-252.
27. Das A, Lenka NK, Sudhishri S, Patnaik US. Influence of integrated nutrient management on production, economics and soil properties in tomato (*Lycopersicon esculentum*) under on-farm condition in Eastern Ghats of Orissa. Indian Journal of Agricultural Sciences. 2008;78:40-43.
28. Balai ML, Verma A, Nepalia V, Kanthaliya PC. Productivity and quality of maize (*Zea mays* L.) as influenced by integrated nutrient management under continuous cropping and fertilization. Indian Journal of Agricultural Sciences. 2011;81:374-376.

29. Mahala HL, Shaktawat MS, Shivran RK. Direct and residual effect of sources and levels of phosphorus and farmyard manure in maize (*Zea mays* L.) -mustard (*Brassica juncea*) cropping sequence. Indian Journal of Agronomy. 2006;51:10-13.
30. Panwar AS. Effect of integrated nutrient management in maize (*Zea mays* L.) – mustard (*Brassica campestris* var. *toria*) cropping system in mid hills altitude. Indian Journal of Agricultural Sciences. 2008;78:27-31.

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