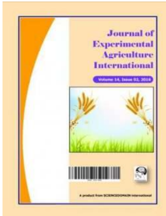

Journal of Experimental Agriculture International

16(3): 1-11, 2017; Article no.JEAI.32574
Previously known as American Journal of Experimental Agriculture
ISSN: 2231-0606

Effect of Soil and Foliar Nitrogen Application on Growth, Yield and Quality of Baby Corn Cultivars

M. P. Neupane[1*], S. P. Singh[2], U. Sai Sravan[2] and Abhishek Singh[2]

[1]Department of Agronomy, Institute of Agriculture and Animal Sciences, Tribhuvan University, Lamjung Campus, Lamjung, Nepal.
[2]Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221 005, Uttar Pradesh, India.

Authors' contributions

This work was part of Ph.D thesis work of author MPN carried out at Banaras Hindu University. Author MPN performed the study design, data collection, lab and statistical analyses under the supervision of author SPS. Authors USS and AS helped in preparation of manuscript, graphs and statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2017/32574
Editor(s):
(1) Slawomir Borek, Department of Plant Physiology, Adam Mickiewicz University, Poland.
(2) T. Muthukumar, Root & Soil Biology Laboratory Department of Botany, Bharathiar University, India.
(3) Mintesinot Jiru, Department of Natural Sciences, Coppin State University, Baltimore, USA.
Reviewers:
(1) Mohammed Suleiman, Umaru Musa Yar'adua University, Katsina, Nigeria.
(2) Burhan Kara, Süleyman Demirel University, Isparta, Turkey.
(3) Shelley Gupta, JJT University, Rajasthan, India and P G Moze College of Engineering, Pune, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/19117

Received 2nd March 2017
Accepted 1st May 2017
Published 18th May 2017

Original Research Article

ABSTRACT

An imperative nitrogen management schedule attempted for the first time using soil application fb (followed by) foliar application at harvest stage to improve productivity and quality of baby corn. A two year study carried out in winter season with three cultivars and six schedules of recommended dose of nitrogen (RDN) application. Nitrogen scheduling in two, three and four splits compared on composite and hybrid cultivars. Crop growth, productivity traits, picking wise cob and corn yields, quality, plant nutrient ratios and nutrient harvest indices were determined. Cultivars followed the order HM-4>HQPM-1>Azad Uttam for yield components, yield and quality. HM-4 gave 7.0% and 31.6% higher mean baby corn yields than HQPM-1 and Azad Uttam. Soil fb foliar RDN application

**Corresponding author: E-mail: mpneupane66@gmail.com;*

in 4 splits [50% as basal (B), 25% at knee height stage (KHS), 20% at tassel emergence (TE) fb 5% foliar spray after first picking (FSAFP)] recorded higher yield attributes, baby cob and corn yields, and quality. Cultivars and N application schedules influenced nutrient ratios. Nutrient harvest indices also varied in response to N application schedule. HM-4 can be cultivated with RDN (150 kg ha^{-1}) in 4 splits (soil fb foliar) for attaining better yield and quality of winter baby corn. Further studies are required for better understanding of combined approach under diverse conditions.

Keywords: Winter baby corn; nitrogen application schedules; combined approach; plant nutrient ratios; nutrient harvest indices.

1. INTRODUCTION

Baby corn is an unfertilized dehusked baby cob harvested after emergence of 2-3 cm long silk [1]. Baby corn is a new crop for India and recently cultivation started in several states. Agro-techniques for baby corn differ from maize because of shorter crop duration and production of more baby cobs. Selection of suitable cultivar and proper nutrient supply particularly nitrogen are the major agro-techniques for achieving higher baby corn productivity. Medium stature, prolific and early maturing single cross hybrids have better yield potentiality than composites. Non availability of suitable cultivar may cause 30-45% reduction in yield [2]. Differential response of maize hybrids to utilize applied nitrogen depends on their genetic ability [3]; however, management practices play an important role in exploitation of the genetic potential.

Potential yield realization of baby corn requires addition of sufficient nitrogen coinciding with the critical growth stages. Studies so far favors soil application of nitrogen in two or three splits at critical growth stages. Nitrogen application time is crucial to match with crop requirement [4,5]. Urea applied as foliar spray in appropriate concentrations especially during tasseling to seed filling stage increased the productivity of baby corn [6,7]. Foliar application at anthesis or during next two weeks enhanced nitrogen content in corn grain [8]. A close relationship observed between maize productivity and N, P and K uptake by whole plant and grain. Nutrient content increases as whole plant biomass and subsequently the grain yield [9].

Suitable environmental conditions, longer duration and harvest period during winters provided ample opportunities for foliar nitrogen application. Informations regarding winter baby corn are scare in India. There is need to rethink nitrogen management for its enhanced utilization by crop. No prior information is available hence, combined approach is attempted for the first time in winter baby corn. We hypothesize that combined approach of soil fb foliar application of nitrogen may improve yield and quality of baby corn. The objective of this study was to analyze the effect of cultivars and nitrogen (N) application schedules on growth, yield and quality parameters of baby corn.

2. MATERIALS AND METHODS

2.1 Treatments and Cultural Practices

Field experiments were conducted during 2011-12 and 2012-13 winter seasons at Agricultural Research Farm (25° 27'N, 82° 99'E), Banaras Hindu University, Varanasi, Uttar Pradesh, India. Soil of the experimental site was sandy clay loam, having 0.33% organic carbon content, EC 0.33 dSm^{-1}, pH 7.4, 191.3 kg ha^{-1} of available N [10], 18.9 kg ha^{-1} of phosphorus (P) [11], 181.2 kg ha^{-1} of potassium (K) [12], 17.7 kg ha^{-1} of sulfur (S) [13] and 0.48 mg kg^{-1} of zinc (Zn) [14]. Factorial experiment was laid out following Randomized Complete Block Design with three replications. Three cultivars and six nitrogen application schedules were tested (Table 1). Plots were twelve rows, 4.8 m wide (40 cm row spacing) and 4.0 m in length. The uniform seed rate of 40 kg per ha adopted for raising the test crops. Recommended dose of nutrients were applied i.e. N, P, K, S and Zn (150-75-60-40-10 kg ha^{-1}). Recommended dose of nitrogen (RDN) was applied at the rate of 150 kg ha^{-1} as per treatments schedule while remaining nutrients were applied as basal (B). Urea, diammonium phosphate, muriate of potash, gypsum and zinc sulphate were used as fertilizer sources. Nitrogen management schedule involved two approaches i.e. soil application and soil application followed by (fb) foliar nitrogen supplementation as urea solutions (3%). Foliar spray after first picking (FSAFP) applied to the top of crop canopy in the respective treatments to provide a total of 7.5 kg N ha^{-1} (5% RDN). The crop was harvested after 102 and 108 days after sowing (DAS) during first and second year respectively. Experimental site represents sub-tropical climate and received total rainfall of 31.80 mm and 6.40 mm during first and second growing season, respectively.

2.2 Morphophysiological Measurements

Chlorophyll content (SPAD value) measurements were taken using Konica Minolta SPAD- 502 Chlorophyll Meter (Konica Minolta Sensing Americas, Inc., Ramsey, NJ). Crop growth rate and relative growth rate computed as difference between dry matters accumulations, and by measuring difference between natural logarithm of dry matter accumulation divided by the time interval of observation [15].

Barren plants ha^{-1}, barrenness (%) and days taken to 50% silking (from three middle rows of each plot) were recorded. Baby cob weight and corn weight from each net plot were recorded and their ratio was expressed as cob: corn ratio. A maximum of four cobs / plant harvested from each net plot recorded as picking wise baby cob and corn yields and expressed in kg/ha.

2.3 Plant Nutrient Content and Quality Analysis

For nutrient content destructive sampling from the border rows were taken at final harvest. Samples of baby corn and above ground whole plant were dried to constant weight at 70^{0}C for 24 hours and used for chemical estimation. N, P and K content were estimated according to Jackson [12]. The nutrient harvest indices viz., N harvest index (NHI), P harvest index (PHI) and K harvest index (KHI) were determined as the ratio between baby corn and whole plant N, P and K contents at maturity [16]. Carbohydrate content [17], sugar content [18] and starch content [19] were estimated and expressed in percentage.

2.4 Statistical Analysis

An analysis of variance (ANOVA) performed using SPSS (version 23). The analysis was based on two factors i.e. cultivars and nitrogen application schedules. All factors (cultivars, nitrogen application schedules) including year and replication was considered fixed factors. Respective graphs were prepared in Microsoft excel.

3. RESULTS AND DISCUSSION

3.1 Growth Characters

Hybrids HM-4 and HQPM-1 possessed higher SPAD values than composite Azad Uttam at 45 and 60 DAS (P = 0.05) (Fig. 1). Mean SPAD readings of hybrids ranged from 46.6 to 57.3 across all sampling times [20]. Recommended N dose in two splits (N_1) recorded maximum SPAD value at 45 DAS while at 60 DAS it was with three splits (N_3). Result indicates that effect of split application was more pronounced at later stage of the crop growth (60 DAS). Overall, application of full nitrogen in three splits (N_3 and N_5) resulted in significantly higher chlorophyll content closely followed by four splits (N_4 and N_6). Delayed application of half of the RDN at TE (N_2) resulted in minimum chlorophyll content irrespective of the crop growth stages. Significance of nitrogen application time for its efficient utilization at various plant growth stages has been advocated by other workers [4,21].

Table 1. Cultivar and nitrogen application schedule treatments

Treatments	Symbol used
Cultivar	
HM - 4	V_1
HQPM - 1	V_2
Azad Uttam	V_3
Nitrogen application schedule	
50% RDN as basal (B) + 50% RDN at Knee high stage (KHS)	N_1
50% RDN as B + 50% RDN at Tassel emergence (TE)	N_2
50% RDN as B + 25% RDN at KHS + 25% RDN at TE	N_3
25% RDN as B + 50% RDN at KHS + 25% RDN at TE	N_4
50% RDN as B + 25% RDN at KHS + 20% RDN at TE + 5% RDN after first picking as foliar spray (FSAFP)	N_5
25% RDN as B + 50% RDN at KHS + 20% RDN at TE + 5% RDN as FSAFP	N_6

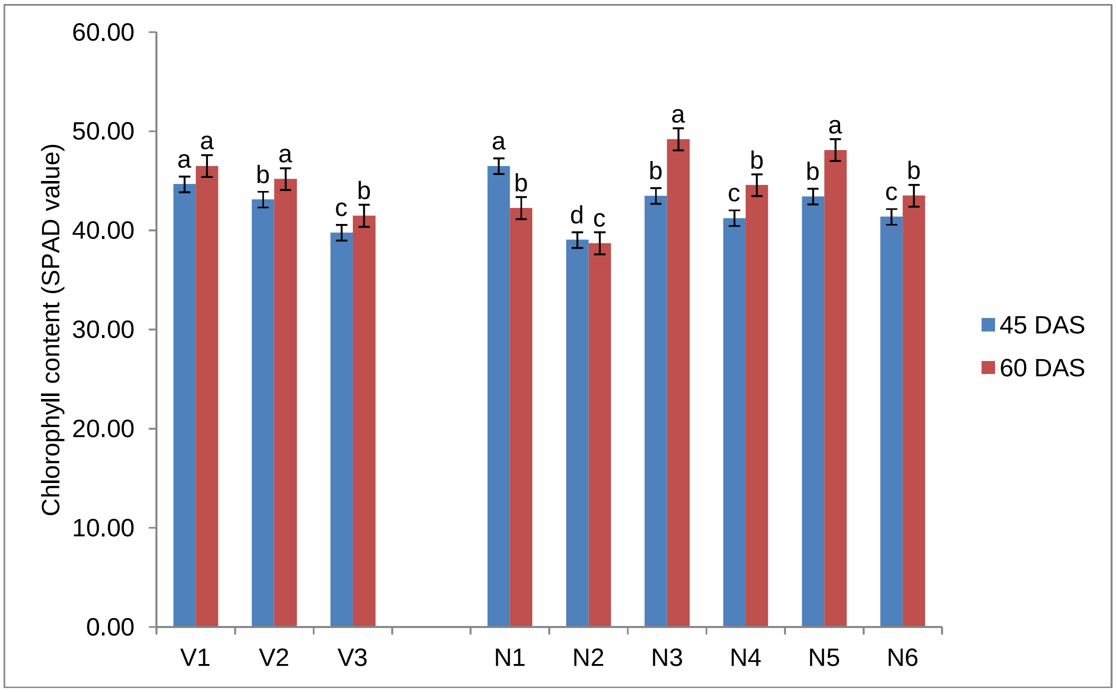

Fig. 1. Chlorophyll content (SPAD value) at 45 and 60 DAS of baby corn evaluated at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

V_1 - HM-4, V_2 - HQPM-1, V_3 - Azad Uttam, N_1 - 50% B + 50% KHS, N_2 - 50% B + 50% TE, N_3 - 50% B + 25% KHS + 25% TE, N_4 - 25% B + 50% KHS + 25% TE, N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP, N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking. Error bars indicate standard error of the mean. Bars bearing same letter(s) are not significantly different

Crop growth rate (CGR) (Fig. 2) was slow initially up to 30 DAS and then rapidly increased between 30-45 DAS, thereafter declined considerably during 45-60 DAS. Higher values noted with composite Azad Uttam over hybrids HQPM-1 and HM-4 (P = 0.05). Variation in CGR may be due to the genetic characteristics of cultivars which caused differences in their dry matter accumulation. Reduction in growth rate with plant age was obvious since crop growth increased progressively with time to attain peak and thereafter declined. Split nitrogen application schedules caused variation in CGR except at early crop stage (0-15 DAS). Results of the present study clearly indicates the influence of time and quantity of N applied on the growth parameters studied. At 15-30 DAS, higher CGR noticed when crop received half of the RDN as basal application (N_1, N_2, N_3 and N_5). At 30-45 DAS application of entire RDN early in two splits (N_1) resulted in maximum CGR closely followed by three splits (N_3) and four splits (N_5), respectively (P = 0.05). At later growth stage (45-60 DAS), N applied in three splits was superior to four and two splits, respectively. Proper nitrogen supply can positively affect crop growth rate because of increased chlorophyll content, enhanced photosynthetic capacity and rapid dry matter accumulation.

Relative growth rate (RGR) (Fig. 3) enhanced during vegetative phase up to 45 DAS and then reduced to a great extent. Maximum RGR shown by the cultivar Azad Uttam followed by HQPM-1 and HM-4 up to 45 DAS however, reverse trend noted between 45-60 DAS. Effect of nitrogen application schedule on RGR was visible only with advancement in vegetative growth phase (30-45 DAS and 45-60 DAS) and no significant difference visible during early crop growth stages. Response to treatments suggests that reduced number of splits with late soil application (TE) of more nitrogen (N_2) greatly reduced RGR. Reduced number of splits (N_1) and addition of entire nitrogen at earliest could accelerate RGR only up to 45 DAS. However, increase in number of splits (three and four splits) resulted maximum RGR at 45-60 DAS irrespective of soil or combined (soil + foliar) application of nitrogen.

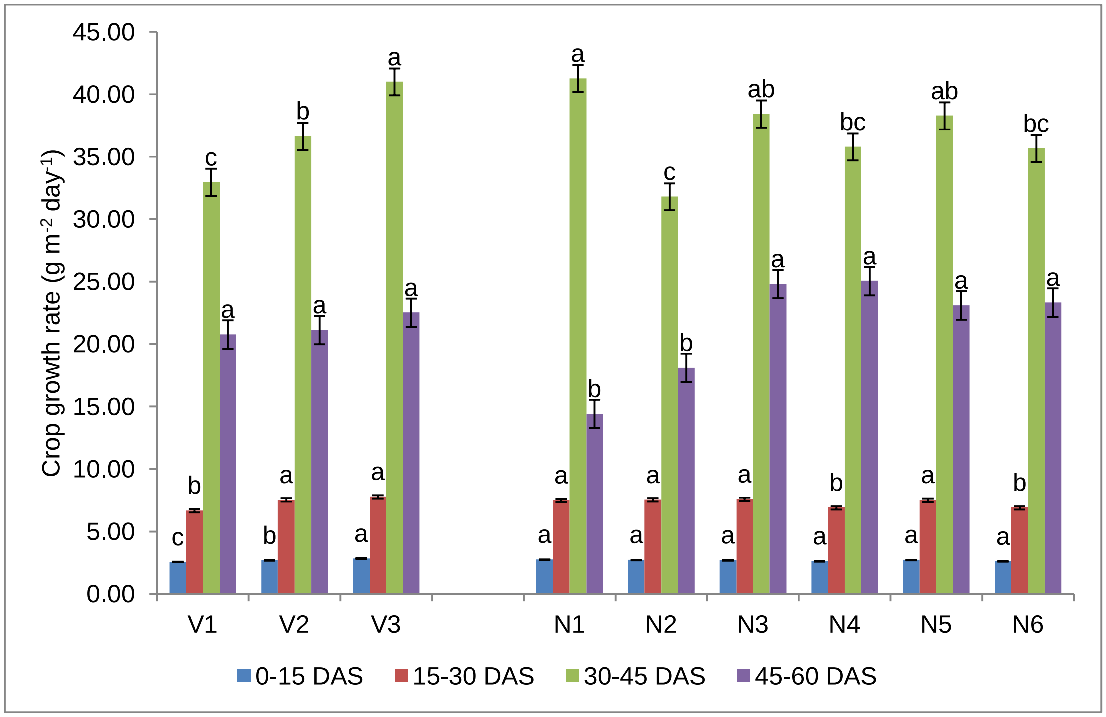

Fig. 2. Crop growth rate of baby corn during vegetative stage evaluated at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

V_1 - HM-4, V_2 - HQPM-1, V_3 - Azad Uttam, N_1 - 50% B + 50% KHS, N_2 - 50% B + 50% TE, N_3 - 50% B + 25% KHS + 25% TE, N_4 - 25% B + 50% KHS + 25% TE, N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP, N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking. Error bars indicate standard error of the mean. Bars bearing same letter(s) are not significantly different

Barrenness (%) and days taken to 50% silk emergence altered because of cultivars and remain unaffected by nitrogen application schedules (Table 2). Barren plants ha^{-1} varied due to cultivars and nitrogen application schedules (*P* = 0.05). Barren plants ha^{-1} and barrenness (%) noted minimum with cultivar HM-4 while it was higher with Azad Uttam. Higher barrenness of composite cultivars than hybrids has been reported [22]. Variability in barrenness (%) is significantly influenced by the cultivars and higher degree of barrenness indicates poor development of sinks and reduced translocation of photosynthates. Hybrid HQPM-1 took more number of days for 50% silk emergence over rest of cultivars. Fast growth of cultivar Azad Uttam resulted in early silk emergence. Results support the findings of [23]. Barren plants per unit area have been found to increase to a significant extent with reduction (two) in number of splits of nitrogen application from 3 or 4. Increase in number of splits might have facilitated enhanced availability and better opportunity for efficient nitrogen utilization.

3.2 Yield Attributes and Picking Wise Yield

Cob weight and cob: corn ratio (Table 2) differed due to cultivars (*P* = 0.05). Hybrids produced heavier cobs (HM-4: 39.96 g, HQPM-1: 38.81 g) than composite Azad Uttam (36.13 g). Hybrids were at par and claimed narrow cob: corn ratio than composite cultivar. HM-4 performed best and this could be attributed to the differential behaviour of the cultivars which created variation in their specific attributes implying as characteristic of genotypes [24]. Recommended nitrogen applied in four splits (N_5) produced greatest baby cob weight however, three splits (N_3) also gave similar baby cob weight (*P* = 0.05). Lowest cob weight recorded when N was applied in two equal splits (N_2). Nitrogen application schedule failed to influence baby cob: corn ratio. In general, increased splits (3/4) were more conducive for regulating nitrogen supply over less number of splits (2) for the crop plant. Further, appropriate partitioning and right time application of nitrogen dose (N_3 and N_5)

augmented the overall effect. Nitrogen application in considerable amount near to anthesis results enhanced possibility of its accumulation in the sink than in other vegetative parts [25].

Overall, picking wise baby cob and corn yield followed the pattern of yield attributes and were in the order of II>I>III>IV, respectively (Figs. 4 and 5). Significant disparity existed among cultivars, and in 1st picking HQPM-1 produced higher baby cob and corn yields while from 2^{nd} to 4^{th} pickings HM-4 was high yielder. Of the total yields, only a small fraction received as 4th picking by hybrids. Azad Uttam failed in production of 4^{th} cob and gave lowest yield among the test cultivars. Results are in agreement with the earlier findings of Pandey et al. [26]. Hybrid HM-4 was superior in productivity traits evaluated over others because of low barrenness, heavier cob weight and narrow cob: corn ratio.

Nitrogen application schedules followed the order N_5>N_3>N_6>N_4>N_1>N_2 for cob and corn yields (P = 0.05). Soil + foliar application treatments (N_5 and N_6) were actually derived by modifying treatments of nitrogen application in three splits. Utilization of 5% RDN as FSAFP (4 splits: N_5 and N_6) enhanced baby cob and corn yields in subsequent three pickings received after the foliar application. Results clearly show that N application in four splits produced significantly higher baby cob and corn yields over soil application in two splits (N_1 and N_2). Further, treatments N_5 and N_6 though found at par with soil application of N in three splits (N_3 and N_4) but were better yielders. Results establish the positive effect of foliar nitrogen application at harvest when combined to soil applications. Highest baby cob and corn yields by treatment N_5 (4 splits) calls for reallocation of N dose at right time and mode for efficient utilization. Nitrogen applied in three splits (N_3) ranked second in performance and found statistically similar to N_5 (4 splits). The results were in accordance with Neupane et al. [27]. Both of above treatments proved superior to rest N application schedules. Results suggests that more splits (three) as soil applications are beneficial and further adding foliar urea spray to it enhances nitrogen utilization by the crop. Increased response to foliar urea is expected when nitrogen availability via soil is reduced. Application timings with variable N rates also affected the baby cob and corn yields. This could be ascertained by comparing between the treatments having similar number of splits i.e. N_1 & N_2, N_3 & N_4, N_5 & N_6. Similar results reported by many workers [7,5].

Table 2. Barren plants, barrenness, 50% silk emergence, cob weight and cob: corn ratio of baby corn grown at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

Treatments	Barren plants (No. ha^{-1})	Barrenness (%)	50 % silk emergence (days)	Cob weight (g)	Cob: corn ratio
V_1 - HM-4	5224.87b	4.51b	75.04b	39.96a	4.77b
V_2 - HQPM-1	5313.05b	4.61b	79.70a	38.81a	4.82b
V_3 - Azad Uttam	7186.95a	6.30a	71.30c	36.13b	5.12a
SEM ±	66.94	0.07	0.90	0.34	0.05
CD (p=0.05)	203.45	0.20	2.81	1.05	0.17
N_1 - 50% B + 50% KHS	6040.56ab	5.24a	76.01a	37.62b	4.92a
N_2 - 50% B + 50% TE	6128.75a	5.33a	76.98a	34.19c	4.94a
N_3 - 50% B + 25% KHS + 25% TE	5776.01ab	5.02a	73.09a	40.52a	4.88a
N_4 - 25% B + 50% KHS + 25% TE	5864.20ab	5.11a	75.62a	38.19b	4.91a
N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP	5687.83b	4.95a	74.97a	40.93a	4.87a
N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP	5952.38ab	5.19a	75.41a	38.35b	4.90a
SEM ±	94.66	0.09	1.28	0.48	0.08
CD (p=0.05)	287.72	0.29	3.97	1.49	0.24

SEM, standard error of mean. Means bearing same letter(s) in a column are not significantly different

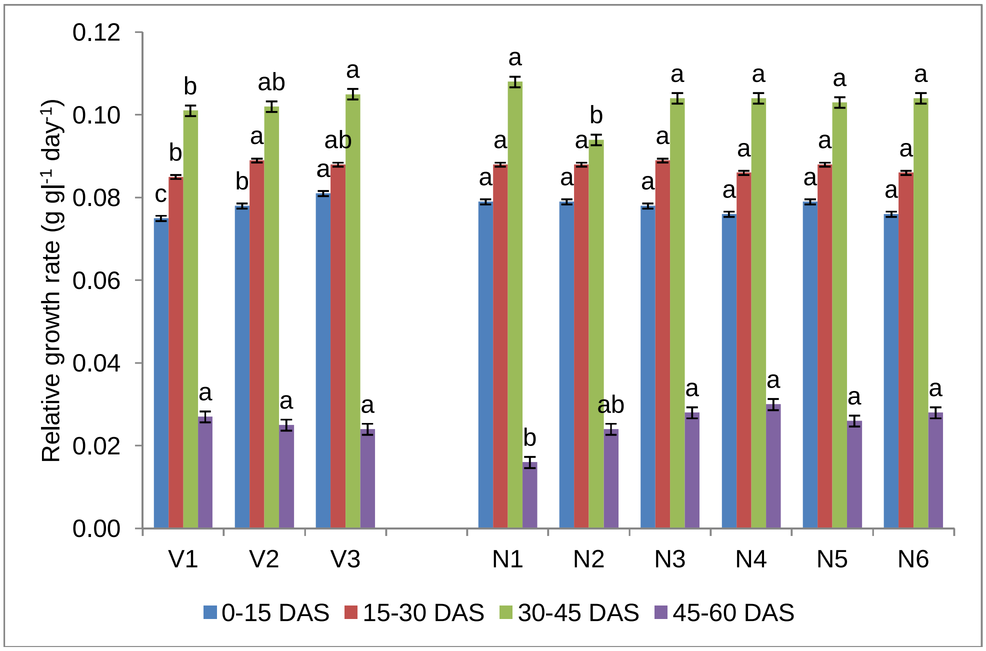

Fig. 3. Relative growth rate of baby corn during vegetative stage evaluated at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

V_1 - HM-4, V_2 - HQPM-1, V_3 - Azad Uttam, N_1 - 50% B + 50% KHS, N_2 - 50% B + 50% TE, N_3 - 50% B + 25% KHS + 25% TE, N_4 - 25% B + 50% KHS + 25% TE, N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP, N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking. Error bars indicate standard error of the mean. Bars bearing same letter(s) are not significantly different

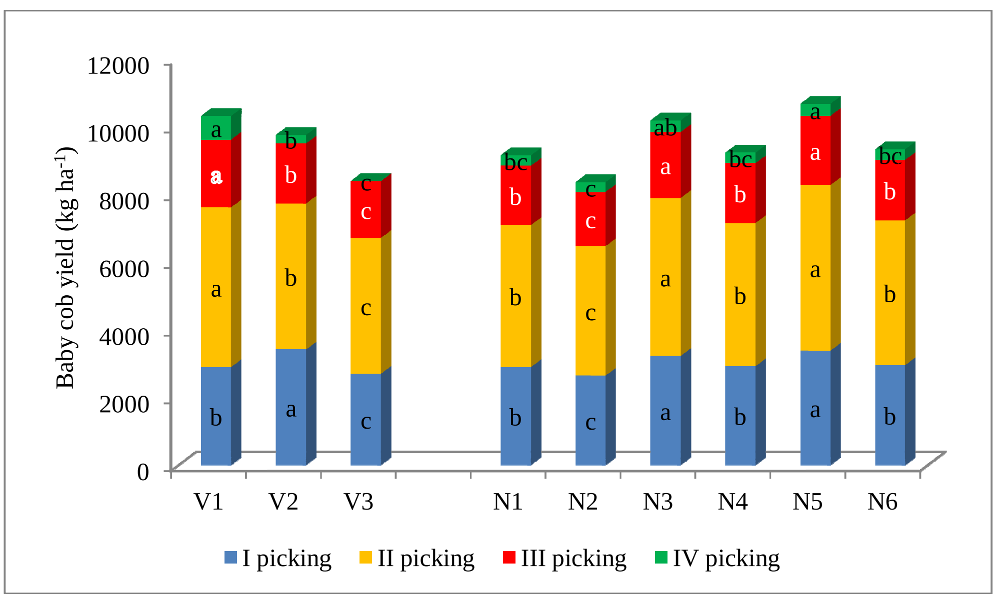

Fig. 4. Baby cob yield evaluated at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

V_1 - HM-4, V_2 - HQPM-1, V_3 - Azad Uttam, N_1 - 50% B + 50% KHS, N_2 - 50% B + 50% TE, N_3 - 50% B + 25% KHS + 25% TE, N_4 - 25% B + 50% KHS + 25% TE, N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP, N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking. Bars bearing same letter(s) are not significantly different

3.3 Quality Parameters

The cultivars differ significantly (P = 0.05) with respect of carbohydrate content (%), starch content (%) and sugar content (%) in baby corn (Table 3). Higher values were recorded with HM-4 followed by HQPM-1 and Azad Uttam. Better quality parameters may be attributed to the differences in genetic factor as well as the leading cultivar (HM-4) adapted well to the environment. These results confirm the findings of Chauhan et al. [23]. Application of nitrogen in three splits (N_3) or four splits (N_5) showed highest and similar values of quality characters. Analysis of variance revealed above two treatments recorded significantly higher values (P = 0.05) of quality characters than other treatments. Foliar application of nitrogen at later stages of crop growth might have resulted into higher nitrogen accumulation in the green cob and increased biochemical reactions. Higher quality parameters noticed due to split application of N [28].

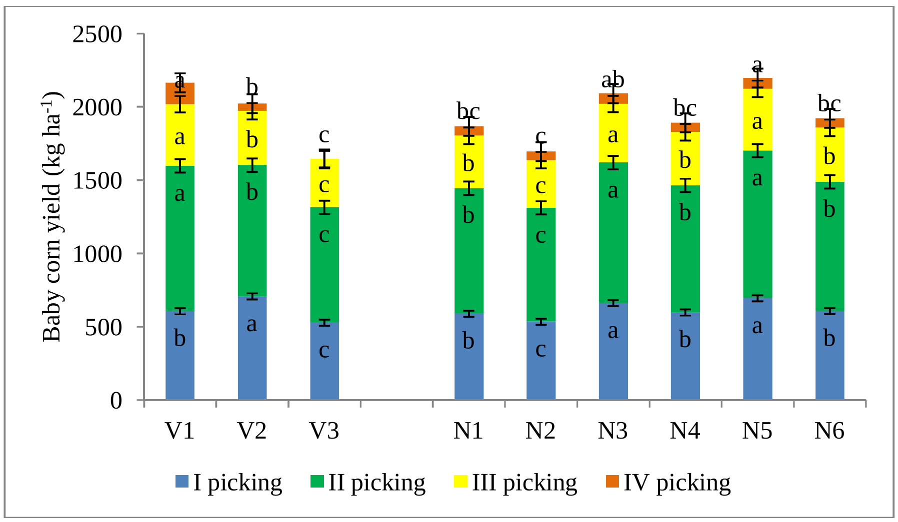

Fig. 5. Baby corn yield evaluated at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

V_1 - HM-4, V_2 - HQPM-1, V_3 - Azad Uttam, N_1 - 50% B + 50% KHS, N_2 - 50% B + 50% TE, N_3 - 50% B + 25% KHS + 25% TE, N_4 - 25% B + 50% KHS + 25% TE, N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP, N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking. Error bars indicate standard error of the mean. Bars bearing same letter(s) are not significantly different

Table 3. Quality parameters of baby corn evaluated at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

Treatments	Carbohydrate content (%)	Starch content (%)	Sugar content (%)
V_1 - HM-4	70.05a	64.82a	1.58a
V_2 - HQPM-1	67.45b	61.56b	1.53b
V_3 - Azad Uttam	64.57c	58.10c	1.37c
SEM ±	0.41	0.58	0.01
CD (p=0.05)	1.21	1.69	0.03
N_1 - 50% B + 50% KHS	64.84c	58.55c	1.47b
N_2 - 50% B + 50% TE	61.76d	54.96d	1.39c
N_3 - 50% B + 25% KHS + 25% TE	71.57a	65.64a	1.56a
N_4 - 25% B + 50% KHS + 25% TE	68.06b	62.23b	1.48b
N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP	71.18a	65.37ab	1.58a
N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP	66.72bc	62.21b	1.49b
SEM ±	0.58	0.81	0.01
CD (p=0.05)	1.72	2.39	0.04

SEM, standard error of mean. Means bearing same letter(s) in a column are not significantly different

Table 4. Plant nutrient ratios and nutrient harvest indices of baby corn evaluated at three cultivars and six nitrogen application schedules (Pooled analysis of 2-years)

Treatments	Plant nutrient ratios		Nutrient harvest indices		
	N/P ratio	N/K ratio	NHI	PHI	KHI
V_1 - HM-4	6.34b	1.28a	0.40a	0.49a	0.33a
V_2 - HQPM-1	6.43b	1.24b	0.40a	0.51a	0.32ab
V_3 - Azad Uttam	6.88a	1.22c	0.41a	0.49a	0.32b
SEM ±	0.07	0.01	0.003	0.005	0.002
CD (p=0.05)	0.19	0.02	0.01	0.01	0.01
N_1 - 50% B + 50% KHS	6.48a	1.21c	0.41a	0.50abc	0.32abc
N_2 - 50% B + 50% TE	6.68a	1.17d	0.41a	0.52a	0.31d
N_3 - 50% B + 25% KHS + 25% TE	6.46a	1.29a	0.40a	0.48bc	0.33ab
N_4 - 25% B + 50% KHS + 25% TE	6.59a	1.23bc	0.40a	0.50ab	0.32cd
N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP	6.53a	1.32a	0.40a	0.47c	0.33a
N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP	6.56a	1.25b	0.40a	0.50abc	0.32bcd
SEM ±	0.09	0.01	0.004	0.007	0.002
CD (p=0.05)	0.26	0.02	0.01	0.02	0.01

SEM, standard error of mean. Means bearing same letter(s) in a column are not significantly different

3.4 Whole Plant Nutrient Ratios

At maturity N/P ratio varied due to cultivars only though N/K ratio affected by cultivars and nitrogen application schedules (P = 0.05) (Table 4). The overall N/P ratio began at 6.34 and ended with 6.88 for cultivars. A close relationship expressed between N and P content indicates their proportional association in baby corn. Ratio between N/P is linked with the level of N applied and biomass [29]. The N/K ratio ranged from 1.22 to 1.28 for cultivars and 1.17 to 1.32 for split nitrogen application treatments. In general, reduction in number of N application splits from four to two resulted decline in N/K ratio. At the plant level, modifications in the N/K ratio were more related to evolution in plant N and K contents and dry matter. The complex interaction between N and K has been also reported by [30].

3.5 Nutrient Harvest Indices

The nutrient harvest indices were evaluated (Table 4). NHI (range= 0.40 to 0.41) failed to express any variation because of cultivars and split nitrogen application. PHI (range = 0.47 to 0.52) unaffected with cultivars though, varied due to nitrogen application schedules (P = 0.05). Maximum PHI noted with two splits (N_2) closely followed by three (N_4) and four splits (N_6). KHI (range = 0.32 to 0.33) varied due to cultivars and improved with increase in the number of splits from two to four. Highest values of nutrient harvest indices were for HM-4 while differential response observed for N application schedules. Nutrient uptake requirement estimation by the recent workers reported PHI of 0.84 and KHI of 0.17 [9] and also PHI of 0.67 and KHI of 0.25 [31].

4. CONCLUSION

Study indicates hybrids (HM-4 and HQPM-1) posse's characteristics of elite cultivars and HM-4 found superior thus recommended for commercial production of winter baby corn in Eastern Uttar Pradesh, India. Results confirm that fraction of RDN and its application timings are important in determining the yields and quality of baby corn. New approach in nitrogen management by combining soil application with foliar at harvest stage had positive effect on yield of baby corn. Combined approach using three splits as soil applications fb fourth split as urea foliar spray (3%) after first picking (N_5, i.e. 50% RDN as basal + 25% RDN at KHS + 20% RDN at TE + 5% RDN) produced higher yield attributes, yields and quality. Supplementing soil nitrogen application with 5% RDN (7.5 kg ha^{-1}) as foliar spray (N_5) resulted 5.1% higher baby corn yield than second best soil application treatment (N_3). Quality parameters improved by nitrogen application in three splits (N_3)/four splits (N_5) compared to other N application schedules. At maturity, hybrids possessed lower N/P and higher N/K ratio than composite cultivar. N/K ratio increased with number of splits. Winter baby corn be grown using cultivar HM-4 adopting RDN

(150 kg ha^{-1}) as soil + foliar application (N_5) for achieving higher yield, quality, nutrient harvest index and nutrient ratio. Further studies required for better understanding of combined approach under diverse conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh MK, Singh RN, Singh SP. Effect of integrated nutrient management on growth, yield and yield attributes of baby corn (*Zea mays*). Veg. Sci. 2009;36:77-79.
2. Das S, Ghosh G, Kaleem MD, Bahadur V. Effect of different levels of nitrogen and crop geometry on the growth, yield and quality of baby corn (*Zea mays* L.) cv Golden Baby. Acta Hort. 2009;809:161-166.
3. Paponov IA, Engels C. Effect of nitrogen supply on leaf traits related to photosynthesis during grain filling in two maize genotypes with different N efficiency. J Pl. Nut. Soil Sci. 2003;166: 756-763.
4. Pearson CM. Plant response to the management of fluid and solid N fertilizers applied to furrow irrigated corn. Fert. Res. 1994;37:51-58.
5. Lehrsch GA, Sojka RE, Westerman DT. Nitrogen placement, row spacing and furrow irrigation-water positioning effects on corn yield. Agron. J. 2000;92:1266-1275.
6. Amanullah, Yasir M, Khalil SK, Jan MT, Khan AZ. Phenology, growth and grain yield of maize as influenced by foliar applied urea at different growth stages. J Plant Nutr. 2010;33:71-79.
7. Sarakhsi HS, Yarnia M, Amirniya R. Effect of nitrogen foliar application in different concentration and growth stage of corn (hybrid-704). Adv. Environ. Biol. 2010;4: 291-298.
8. Gooding MJ, Davies WP. Foliar urea fertilization of cereals: A review. Fert. Res. 1992;32:209-222.
9. Setiyono TD, Walters DT, Cassman KG, Witt C, Dobermann A. Estimating maize nutrient uptake requirements. Field Crops Res. 2010;118:158-168.
10. Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. Curr. Sci. 1973;28:259-260.
11. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. US Department of Agriculture Circular number 939, USDA, Washington, DC; 1954.
12. Jackson ML. Soil chemical analysis. Prentice- Hall of India Pvt. Ltd., New Delhi; 1973.
13. Chesnin L, Yien CH. Turbidimetric determination of available sulphate. Soil Sci. Soc. Am. Proc. 1950;15:149-151.
14. Lindsay WL, Norwell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J. 1978;43: 421-428.
15. Radford PJ. Growth analysis formulae, their use and abuse. Crop Sci. 1967;7:171-175.
16. Ciampitti IA, Camberato JJ, Murrell ST, Vyn TJ. Maize nutrient accumulation and partitioning in response to plant density and nitrogen rate: I. Macronutrients. Agron. J. 2013;105:783-795.
17. Hedge JE, Hofrieter BT. In: Carbohydrate chemistry, 17 (Eds. Whistler R.L., Be Miller J.N.), Academic Press, New York; 1962.
18. Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances. Anal. Chem. 1956;28:350-356.
19. Knutson CA, Grove MJ. Rapid method for estimation of amylose in maize starches. Cereal Chem. 1994;71:469-471.
20. Bullock DG, Anderson DS. Evaluation of the Minolta SPAD-502 chlorophyll meter for nitrogen management in corn. J Plant Nutr. 1998;21:741-755.
21. Saleem MF, Randhawa MS, Hussain S, Wahid MA, Anjum SA. Nitrogen management studies in autumn planted maize (*Zea mays* L.) hybrids. J. Anim. Plant Sci. 2009;19:140-143.
22. Thakur DR, Sharma V. Effect of plant geometry on baby corn yield in hybrid and composite cultivar of maize (*Zea mays* L.). Indian J. Agric. Sci. 2000;70:246-247.
23. Chauhan SK, Mohan J, Dass S, Gadag RN. Evaluation and identification of suitable maize cultivars for baby corn productivity traits. Indian J. Plant Genet. Resour. 2009;22:229-238.

24. Castro RS, Silva PSL, Cardoso MJ. Baby corn, green corn and dry corn yield of corn cultivars. Hort. Bras. 2013;31:100-105.
25. Nair KPK, Singh RP. Studies in fractional application of nitrogen to hybrid maize in India. Exp. Agric. 1974;10:257-261.
26. Pandey AK, Prakash V, Mani VP, Singh RD. Effect of rate of nitrogen and time of application on yield and economics of baby corn (*Zea mays* L.). Indian J. Agron. 2000; 45:338-343.
27. Neupane MP, Singh SP, Sai Sravan U. Response of baby corn genotypes to soil and foliar nitrogen application schedule. Arch. Agron. Soil Sci. 2017;1-15. DOI: 10.1080/03650340.2017.1311011
28. Muthukumar VB, Velayudham K, Thavaprakaash N. Effect of plant growth regulators and time of nitrogen application on quality and green cob yield of baby corn (*Zea mays* L.). Madras Agric. J. 2005;92: 545-548.
29. Ziadi N, Belanger G, Cambouris AN, Tremblay N, Nolin MC, Claessens A. Relationship between P and N concentrations in corn. Agron. J. 2007;99: 833-841.
30. Zhang F, Niu J, Zhang W, Chen X, Li C, Yuan L, Xie J. Potassium nutrition of crops under varied regimes of nitrogen supply. Plant Soil. 2010;335:21-34.
31. Ning P, Liao C, Li S, Yu P, Zhang Y, Li X, Li C. Maize cob plus husk mimics the grain sink to stimulate nutrient uptake by roots. Field Crops Res. 2012; 130:38-45.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/19117