

Original Research Article

Effect of soil and foliar nitrogen application on growth, yield and quality of baby corn cultivars

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 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. ~~Nutrient ratios influenced due to c~~Cultivars and N application schedules influenced nutrient ratios. Nutrient harvest indices also varied due-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.

9 *Keywords: Winter baby corn, nitrogen application schedules, combined approach, plant nutrient ratios,*
10 *nutrient harvest indices*

11

12 **1. INTRODUCTION**

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

22 Higher quantity of nitrogen required by the baby corn coinciding with the periods of efficient utilization to
23 exploit its potential. Studies so far favors soil application of nitrogen in two or three splits at critical growth
24 stages. Nitrogen application time is crucial to match with crop requirement [4,5]. Urea applied as Foliar
25 urea sprays in appropriate concentrations especially during tasseling to seed filling stage increased the
26 productivity of and timing can increase baby corn [6,7] productivity. Foliar-N application improved maize
27 grain yield to significant extent [6], foliar spray as urea from tasseling to seed filling increased yield and
28 quality [7]. Foliar application at anthesis or during next two weeks enhanced nitrogen content in corn grain
29 [8]. A close relationship observed between maize productivity and N, P and K uptake by whole plant and
30 grain. Nutrient content increases as whole plant biomass and subsequently the grain yield [9].

31 Suitable environmental conditions, longer duration and harvest period during winters provided ample
32 opportunities for foliar nitrogen application. Informations regarding winter baby corn are scare in India.
33 Foliar applications of nitrogen at harvest stage may enhance baby corn yield and quality. There is need to
34 rethink nitrogen management for its enhanced utilization by crop. No prior information is available hence,
35 this approach is attempted for the first time in winter baby corn. We hypothesize that combined approach

Comment [R1]: Not clear. Rewrite.

Comment [R2]: This is the repeat of the previous sentence. Delete the sentence and add the references to the previous one.

Comment [R3]: This has already been said before.

Comment [R4]: Mention which approach.

36 | ~~(of soil fb foliar application of)~~ in nitrogen ~~management using foliar urea application~~ may improve yield
37 | and quality of baby corn. The objective of this study was to analyze the effect of cultivars and nitrogen ~~(N)~~
38 | application schedules on growth, yield and quality parameters of baby corn.

39 | 2. MATERIALS AND METHODS

40 | 2.1 Treatments and cultural practices

41 | Field experiments were conducted during 2011-12 and 2012-13 winter seasons at Agricultural Research
42 | Farm (25° 27'N, 82° 99'E), Banaras Hindu University, Varanasi, Uttar Pradesh, India. Soil of the
43 | experimental site was sandy clay loam, having 0.33% organic carbon content, EC 0.33 dSm⁻¹, pH 7.4,
44 | ~~available N~~ 191.3 kg ha⁻¹ ~~of available N~~ [10], ~~P~~ 18.9 kg ha⁻¹ ~~of phosphorus (P)~~ [11], ~~K~~ 181.2 kg ha⁻¹ ~~of~~
45 | ~~potassium (K)~~ [12], ~~S~~ 17.7 kg ha⁻¹ ~~of sulfur (S)~~ [13] and ~~Zn~~ 0.48 mg kg⁻¹ ~~of Zinc (Zn)~~ [14]. Factorial
46 | experiment was laid out following Randomized Complete Block Design with three replications. Three
47 | cultivars and six nitrogen application schedules were tested (Table 1). Plots were twelve rows, 4.8 m wide
48 | (40 cm row spacing) and 4.0 m in length. The uniform seed rate of 40 kg per ha adopted for raising the
49 | test crops. Recommended dose of nutrients were applied i.e. N, P, K, S and Zn (150-75-60-40-10 kg ha⁻¹
50 | ¹). Recommended dose of nitrogen (RDN) was applied at the rate of 150 kg ha⁻¹ as per treatments
51 | schedule while remaining nutrients were applied as basal (B). Ureas, diammonium phosphate, muriate of
52 | potash, gypsum and zinc sulphate were used as fertilizer sources. Nitrogen management schedule
53 | involved two approaches i.e. soil application and soil application followed by (fb) foliar nitrogen
54 | supplementation as urea solutions (3%). Foliar spray after first picking (FSAFP) applied to the top of crop
55 | canopy in the respective treatments to provide a total of 7.5 kg N ha⁻¹ (5% RDN). Experimental site
56 | represents sub-tropical climate and received total rainfall of 31.80 mm and 6.40 mm during first and
57 | second growing season, respectively.

58 | 2.2 Morphophysiological measurements

59 | Chlorophyll content (SPAD value) measurements were taken using Konica Minolta SPAD- 502
60 | Chlorophyll Meter (Konica Minolta Sensing Americas, Inc., Ramsey, NJ). Crop growth rate and relative

Comment [R5]: Abbreviation has to be introduced,

61 growth rate computed as difference between dry matters accumulations, and by measuring difference
62 between natural logarithm of dry matter accumulation divided by the time interval of observation [15].

63 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

64
65 Barren plants ha⁻¹, barrenness (%) and days taken to 50% silking (from three middle rows of each plot)
66 were recorded. Baby cob weight and corn weight from each net plot were recorded and their ratio was
67 expressed as cob: corn ratio. A maximum of four cobs / plant harvested from each net plot recorded as
68 picking wise baby cob and corn yields and expressed in kg/ha.

69 2.3 Plant nutrient content and quality analysis

70 For nutrient content destructive sampling from the border rows were taken at final harvest. Samples of
71 baby corn and above ground whole plant were dried to constant weight at 70°C for 24 hours and used for
72 chemical estimation. N, P and K content were estimated [as suggested by according to Jackson \[12\]](#). The

73 nutrient harvest indices viz., N harvest index (NHI), P harvest index (PHI) and K harvest index (KHI) were
74 determined as the ratio between baby corn and whole plant N, P and K contents at maturity [16].
75 Carbohydrate content ~~as suggested by~~ [17], sugar content [18] and starch content [19] were estimated
76 and expressed in percentage.

77 2.4 Statistical analysis

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

Comment [R6]: Explain why years were not considered as a factor.

82 3. RESULTS AND DISCUSSION

83 3.1 Growth characters

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

Comment [R7]: Use abbreviations

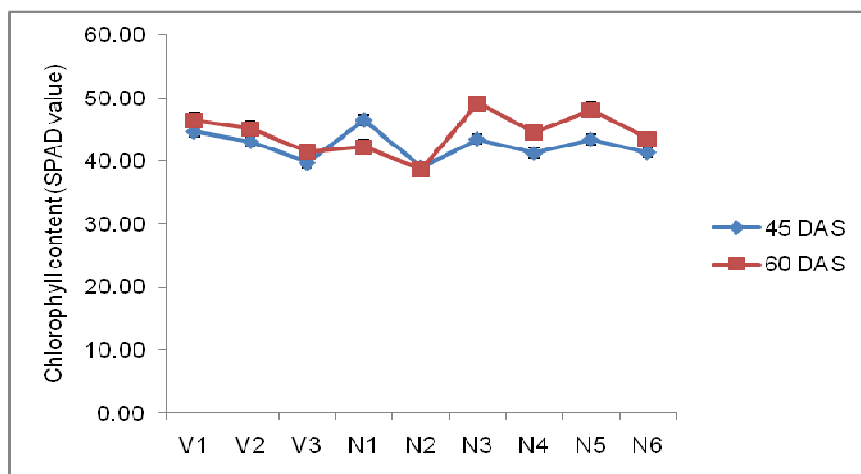


Fig. 1. Chlorophyll content (SPAD value) at 45 and 60 DAS of baby corn evaluated at three cultivars and six nitrogen application schedules. V₁ - HM-4, V₂ - HQPM-1, V₃ - Azad Uttam, N₁ - 50% B + 50% KHS, N₂ - 50% B + 50% TE, N₃ - 50% B + 25% KHS + 25% TE, N₄ - 25% B + 50% KHS + 25% TE, N₅ - 50% B + 25% KHS + 20% TE + 5% FSAFP, N₆ - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking

Comment [R8]: Why post hoc was not performed? Perform Post Hoc analysis and present the mean separations in the figure.

Crop growth rate (CGR) (Fig. 2) found was slow initially up to 30 DAS and observed most 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. 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 indicated ds the significance influence of time and quantity of N applied. At 15-30 DAS, higher CGR noticed when crop received half of the RDN as basal application (N₁, N₂, N₃ and N₅). At 30-45 DAS application of entire RDN early in two splits (N₁) resulted in maximum CGR closely followed by three splits (N₃) and four splits (N₅), respectively. At later growth stage (45-60 DAS), N applied in three splits was superior to four and two splits, respectively. Proper nitrogen

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supply can positively affect crop growth rate because of increased chlorophyll content, enhanced photosynthetic capacity and rapid dry matter accumulation.

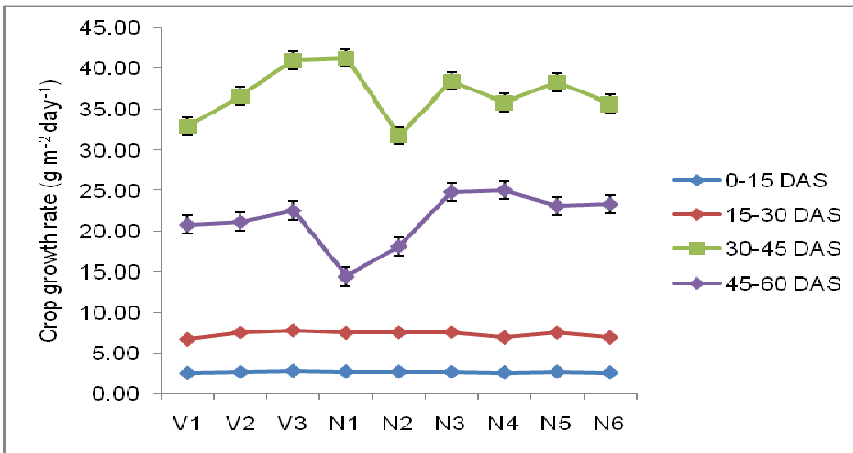


Fig. 2. Crop growth rate of baby corn during vegetative stage evaluated at three cultivars and six nitrogen application schedules. V₁ - HM-4, V₂ - HQPM-1, V₃ - Azad Uttam, N₁ - 50% B + 50% KHS, N₂ - 50% B + 50% TE, N₃ - 50% B + 25% KHS + 25% TE, N₄ - 25% B + 50% KHS + 25% TE, N₅ - 50% B + 25% KHS + 20% TE + 5% FSAFP, N₆ - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking

Comment [R10]: What does the error bars indicate?? Standard deviation or standard error. For other comments see Fig.1.

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 (N₂) greatly reduced RGR. Reduced number of splits (N₁) 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.

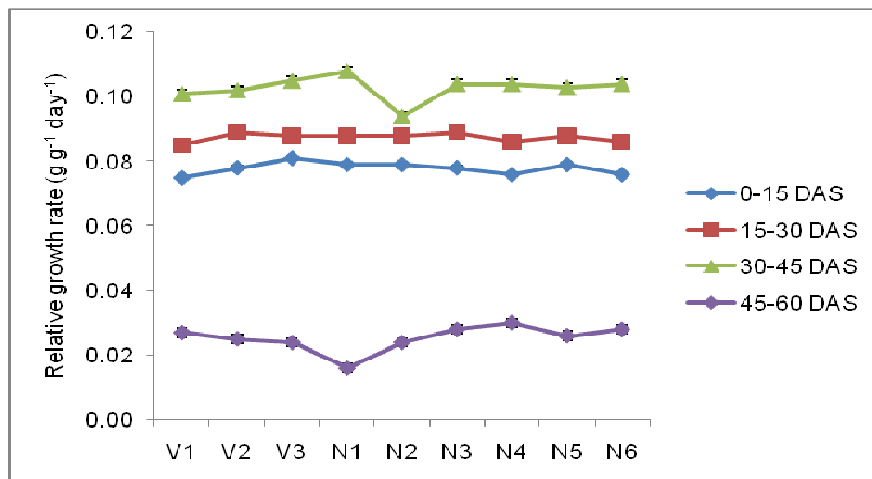


Fig. 3. Relative growth rate of baby corn during vegetative stage evaluated at three cultivars and six nitrogen application schedules. V₁ - HM-4, V₂ - HQPM-1, V₃ - Azad Uttam, N₁ - 50% B + 50% KHS, N₂ - 50% B + 50% TE, N₃ - 50% B + 25% KHS + 25% TE, N₄ - 25% B + 50% KHS + 25% TE, N₅ - 50% B + 25% KHS + 20% TE + 5% FSAFP, N₆ - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel emergence, FSAFP - Foliar spray after first picking

Comment [R11]: See comments for Figs.1 and 2.

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. 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.

Comment [R12]: Is it 'silks'?

3.2 Yield attributes and picking wise yield

Cob weight and cob: corn ratio (Table 2) differed due to cultivars. 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. 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].

Comment [R13]: ????

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

Comment [R14]: You have to present the mean separations.

Treatments	Barren plants (No. ha ⁻¹)	Barrenness (%)	50 % silk emergence (days)	Cob weight (g)	Cob : corn ratio
V ₁ - HM-4	5224.87	4.51	75.04	39.96	4.77
V ₂ - HQPM-1	5313.05	4.61	79.70	38.81	4.82
V ₃ - Azad Uttam	7186.95	6.30	71.30	36.13	5.12
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	6040.56	5.24	76.01	37.62	4.92

N ₂ - 50% B + 50% TE	6128.75	5.33	76.98	34.19	4.94
N ₃ - 50% B + 25% KHS + 25% TE	5776.01	5.02	73.09	40.52	4.88
N ₄ - 25% B + 50% KHS + 25% TE	5864.20	5.11	75.62	38.19	4.91
N ₅ - 50% B + 25% KHS + 20% TE + 5% FSAFP	5687.83	4.95	74.97	40.93	4.87
N ₆ - 25% B + 50% KHS + 20% TE + 5% FSAFP	5952.38	5.19	75.41	38.35	4.90
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

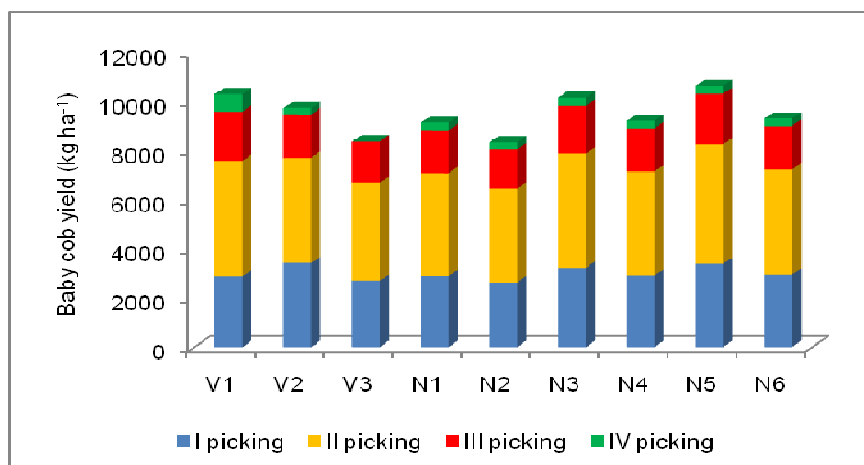
SEM, standard error of mean

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 (Fig. 4 and 5). Significant disparity existed among cultivars seen, and in 1st picking HQPM-1 produced higher baby cob and corn yields while from 2nd to 4th 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 4th 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 N₅>N₃>N₆>N₄>N₁>N₂ for cob and corn yields. Soil + foliar application treatments (N₅ and N₆) were actually derived by modifying treatments of nitrogen application in three splits. Utilization of 5% RDN as FSAFP (4 splits: N₅ and N₆) enhanced baby cob and corn yields in subsequent three pickings received after the foliar application. Results establish the positive effect of foliar nitrogen application at harvest when combined to soil applications. Highest baby cob and corn yields by treatment N₅ (4 splits) calls for reallocation of N dose at right time and mode for efficient

Comment [R15]: This should be proved statistically.

173 utilization. Nitrogen applied in three splits (N_3) ranked second in performance and found statistically
 174 similar to N_5 (4 splits). Both of above treatments proved superior to rest N application schedules. Results
 175 suggests that more splits (three) as soil applications are beneficial and further adding foliar urea spray to
 176 it enhances nitrogen utilization by the crop. Increased response to foliar urea is expected when nitrogen
 177 availability via soil is reduced. Application timings with variable N rates also affected the baby cob and
 178 corn yields. This could be ascertained by comparing between the treatments having similar number of
 179 splits i.e. N_1 & N_2 , N_3 & N_4 , N_5 & N_6 . Similar results reported by many workers [7, 5].



180
 181 **Fig. 4. Cob yield of baby corn evaluated at three cultivars and six nitrogen application schedules.**
 182 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 +
 183 25% KHS + 25% TE, N_4 - 25% B + 50% KHS + 25% TE, N_5 - 50% B + 25% KHS + 20% TE + 5% FSAFP,
 184 N_6 - 25% B + 50% KHS + 20% TE + 5% FSAFP. B - Basal, KHS - Knee height stage, TE - Tassel
 185 emergence, FSAFP - Foliar spray after first picking

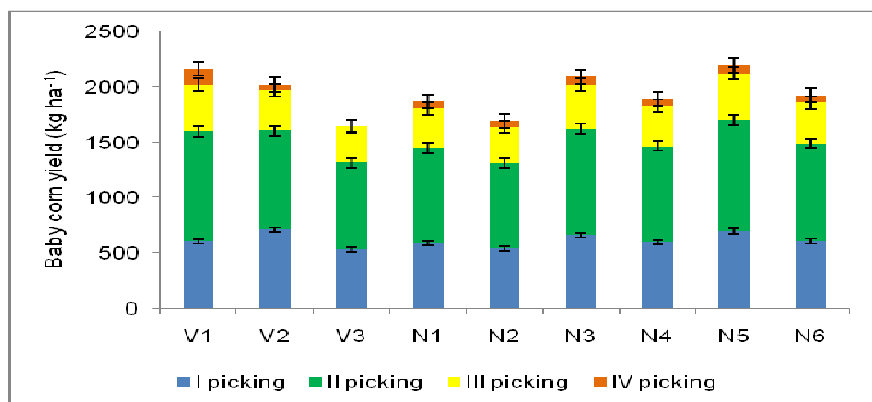


Fig. 5. Corn yield of baby corn evaluated at three cultivars and six nitrogen application schedules.

Comment [R16]: See comments for Figs.1 and 2.

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

3.3 Quality parameters

The cultivars differ significantly 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 [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 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 [27].

Comment [R17]: Include the name.

Table 3. Quality parameters of baby corn evaluated at three cultivars and six nitrogen application schedules

Treatments	Carbohydrate content (%)	Starch content (%)	Sugar content (%)
V ₁ - HM-4	70.05	64.82	1.58
V ₂ - HQPM-1	67.45	61.56	1.53
V ₃ - Azad Uttam	64.57	58.10	1.37
SEM ±	0.41	0.58	0.01
CD (p=0.05)	1.21	1.69	0.03
N ₁ - 50% B + 50% KHS	64.84	58.55	1.47
N ₂ - 50% B + 50% TE	61.76	54.96	1.39
N ₃ - 50% B + 25% KHS + 25% TE	71.57	65.64	1.56
N ₄ - 25% B + 50% KHS + 25% TE	68.06	62.23	1.48
N ₅ - 50% B + 25% KHS + 20% TE + 5% FSAFP	71.18	65.37	1.58
N ₆ - 25% B + 50% KHS + 20% TE + 5% FSAFP	66.72	62.21	1.49
SEM ±	0.58	0.81	0.01
CD (p=0.05)	1.72	2.39	0.04

Comment [R18]: Indicate mean separations

204 SEM, standard error of mean

205 3.4 Whole plant nutrient ratios

206 At maturity N/P ratio varied due to cultivars only though N/K ratio affected by cultivars and nitrogen

207 application schedules (Table 4). The overall N/P ratio began at 6.34 and ended with 6.88 for cultivars. A

208 close relationship expressed between N and P content indicates their proportional association in baby

Comment [R19]: Where is the result of statistical analysis???

corn. Ratio between N/P is linked with the level of N applied and biomass [28]. 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 [29].

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. Maximum PHI noted with two splits (N₂) closely followed by three (N₄) and four splits (N₆). 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 [30].

Table 4. Plant nutrient ratios and nutrient harvest indices of baby corn evaluated at three cultivars and six nitrogen application schedules

Treatments	Plant nutrient ratios		Nutrient harvest indices		
	N/P ratio	N/K ratio	NHI	PHI	KHI
V ₁ - HM-4	6.34	1.28	0.40	0.49	0.33
V ₂ - HQPM-1	6.43	1.24	0.40	0.51	0.32
V ₃ - Azad Uttam	6.88	1.22	0.41	0.49	0.32
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	6.48	1.21	0.41	0.50	0.32

N ₂ - 50% B + 50% TE	6.68	1.17	0.41	0.52	0.31
N ₃ - 50% B + 25% KHS + 25% TE	6.46	1.29	0.40	0.48	0.33
N ₄ - 25% B + 50% KHS + 25% TE	6.59	1.23	0.40	0.50	0.32
N ₅ - 50% B + 25% KHS + 20% TE + 5% FSAFP	6.53	1.32	0.40	0.47	0.33
N ₆ - 25% B + 50% KHS + 20% TE + 5% FSAFP	6.56	1.25	0.40	0.50	0.32
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

225 SEM, standard error of mean

226 4. CONCLUSION

227 On the basis of important traits evaluated under this study, hybrids in general (HM-4 and HQPM-1)
228 expressed characteristics of elite cultivars compared to composite Azad Uttam. Hybrid HM-4 found
229 superior for the productivity traits evaluated thus recommended for commercial production of winter baby
230 corn in Eastern Uttar Pradesh, India. Results confirms the earlier findings that fraction of the
231 recommended dose of nitrogen (RDN) and its application timings plays an important role in determining
232 the yields and quality of baby corn. Testing of a new approach in nitrogen management by combining soil
233 application with foliar at harvest stage had positive effect on yield of baby corn. Combined approach using
234 three splits as soil applications scheduled at critical crop growth stages fb fourth split as urea foliar spray
235 (3%) after first picking (N₅, i.e. 50% RDN as basal + 25% RDN at KHS + 20% RDN at TE + 5% RDN)
236 produced higher yield attributes, yields and quality. Supplementing soil nitrogen application with 5% RDN
237 (7.5 kg ha⁻¹) as foliar spray (N₅) resulted 5.1% higher baby corn yield than second best soil application
238 treatment (N₃). Significant improvement in quality parameters noted by nitrogen application in three splits
239 (N₃)/four splits (N₅) compared to other N application schedules. At maturity, hybrids possessed lower N/P
240 ratio than composite cultivar while reverse trend noted for N/K ratio. N/K ratio increased with more

number of splits. Baby corn during winter season be grown using cultivar HM-4 adopting recommended nitrogen dose (150 kg ha^{-1}) as soil + foliar application (N_5) for achieving higher yield, quality, nutrient harvest index and nutrient ratio. Further studies on N management required for better understanding of combined approach utilizing soil and foliar application involving varied genotypes under diverse conditions.

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. Lehrs 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.

- 263 9. Setiyono TD, Walters DT, Cassman KG, Witt C, Dobermann A. Estimating maize nutrient uptake
264 requirements. *Field Crops Res.* 2010;118:158-168.
- 265 10.Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. *Curr. Sci.*
266 1973;28:259-260.
- 267 11.Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soil by extraction
268 with sodium bicarbonate. US Department of Agriculture Circular number 939, USDA, Washington, DC;
269 1954.
- 270 12.Jackson ML. Soil chemical analysis. Prentice- Hall of India Pvt. Ltd., New Delhi; 1973.
- 271 13.Chesnin L, Yien CH. Turbidimetric determination of available sulphate. *Soil Sci. Soc. Am. Proc.*
272 1950;15:149-151.
- 273 14.Lindsay WL, Norwell WA. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil*
274 *Sci. Soc. Am. J.* 1978;43:421-428.
- 275 15.Radford PJ. Growth analysis formulae, their use and abuse. *Crop Sci.* 1967;7:171-175.
- 276 16.Ciampitti IA, Camberato JJ, Murrell ST, Vyn TJ. Maize nutrient accumulation and partitioning in
277 response to plant density and nitrogen rate: I. Macronutrients. *Agron. J.* 2013;105:783-795.
- 278 17.Hedge JE, Hofrieter BT. In: Carbohydrate chemistry, 17 (Eds. Whistler R.L., Be Miller J.N.), Academic
279 press, New York; 1962.
- 280 18.Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of
281 sugars and related substances. *Anal. Chem.* 1956;28:350-356.
- 282 19.Knutson CA, Grove MJ. Rapid method for estimation of amylose in maize starches. *Cereal Chem.*
283 1994;71:469-471.

- 284 20.Bullock DG, Anderson DS. Evaluation of the Minolta SPAD-502 chlorophyll meter for nitrogen
285 management in corn. *J Plant Nutr.* 1998;21:741-755.
- 286 21.Saleem MF, Randhawa MS, Hussain S, Wahid MA, Anjum SA. Nitrogen management studies in
287 autumn planted maize (*Zea mays* L.) hybrids. *J. Anim. Plant Sci.* 2009;19:140-143.
- 288 22.Thakur DR, Sharma V. Effect of plant geometry on baby corn yield in hybrid and composite cultivar of
289 maize (*Zea mays* L.). *Indian J. Agric. Sci.* 2000;70:246-247.
- 290 23.Chauhan SK, Mohan J, Dass S, Gadag RN. Evaluation and identification of suitable maize cultivars for
291 baby corn productivity traits. *Indian J. Plant Genet. Resour.* 2009;22:229-238.
- 292 24.Castro RS, Silva PSL, Cardoso MJ. Baby corn, green corn and dry corn yield of corn cultivars. *Hort.*
293 *Bras.* 2013;31:100-105.
- 294 25.Nair KPK, Singh RP. Studies in fractional application of nitrogen to hybrid maize in India. *Exp. Agric.*
295 1974;10:257-261.
- 296 26.Pandey AK, Prakash V, Mani VP, Singh RD. Effect of rate of nitrogen and time of application on yield
297 and economics of baby corn (*Zea mays* L.). *Indian J. Agron.* 2000;45:338-343.
- 298 27.Muthukumar VB, Velayudham K, Thavaprakash N. Effect of plant growth regulators and time of
299 nitrogen application on quality and green cob yield of baby corn (*Zea mays* L.). *Madras Agric. J.*
300 2005;92:545-548.
- 301 28.Ziadi N, Belanger G, Cambouris AN, Tremblay N, Nolin MC, Claessens A. Relationship between P
302 and N concentrations in corn. *Agron. J.* 2007;99:833-841.
- 303 29.Zhang F, Niu J, Zhang W, Chen X, Li C, Yuan L, Xie J. Potassium nutrition of crops under varied
304 regimes of nitrogen supply. *Plant Soil.* 2010;335:21-34.
- 305 30.Ning P, Liao C, Li S, Yu P, Zhang Y, Li X, Li C. Maize cob plus husk mimics the grain sink to stimulate
306 nutrient uptake by roots. *Field Crops Res.* 2012;130:38-45.