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QUALITY AND ECONOMICS OF BABY CORN (*Zea mays* L.) AS INFLUENCED BY SOWING DATES AND FERTILITY LEVELS UNDER TEMPERATE CONDITIONS

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Maize (*Zea mays* L.) is one of the most important coarse cereals which is widely distributed all around the globe. It is an important staple food in many countries and is also used as animal feed. In India, it is an important crop not only in terms of acreage but also in context to its versatility for adoption under wide range of agro-climatic conditions. Globally maize is cultivated over an area of 190 million hectare with a production of 1438 million tonnes (FAO, 2019). In India area under maize cultivation is about 9.50 million hectares with a production of 27.23 million tonnes annually and productivity is about 2.870 tonnes ha^{-1} (DES, 2019). The predominant maize growing states in India are Andhra Pradesh, Karnataka, Tamil Nadu and Rajasthan. Apart from these states it is also grown in Jammu and Kashmir. In the union territory of Jammu and Kashmir maize is the second most important cereal crop after rice and is grown on an area of 0.31 million hectare with production of 0.51 million tonnes and an average productivity of 1.65 tonnes ha^{-1} (DES, 2019).

Specialty corns *viz.,* baby corn, pop corn, sweet corn etc. assume great market potential in India and the international market as well. For value addition and diversification of maize as well as the growth of the food processing industry, growing maize for vegetable which is known as baby corn, is contemplated. Baby corn is dehusked maize ear which is harvested young especially when the silk has either not emerged or just emerged and no fertilization has taken place or we can say the shank with unpollinated silk is baby corn. The colour of Baby corn is light yellow and is having regular row arrangement. The 10 to 12 cm long and diameter 1 to 1.5 cm arrangement is preferred in the market (Golada *et al*., 2013).Baby corn is very nutritive vegetable and its nutritional quality is at par or even superior to a number of vegetables *viz.,* cabbage, cauliflower, French bean, spinach, tomato, lady finger, radish etc. It contains 81.97% total carbohydrates, 10.04 g/100g crude protein, 4.43g/100g crude fiber, 1.34 g/100g ash, 375.67 calories energy/100g, 0.14g/100g soluble sugars, 17.76mg/100g calcium, 197.89 mg/100g phosphorus and 2.74 mg /100g iron (Kawatra and Seghal, 2007). In addition to its nutritive advantage, it is also free from residual effect of pesticides as it is harvested at young stage within a week of tassel emergence and the young cob is wrapped up tightly within the husk and well protected from insects and pests (Kumar and Thakur, 2004).

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Cultivation of baby corn in India is a recent development. Its cultivation is picking pace in Haryana, Maharashtra, Meghalaya, Western Uttar Pradesh, Andhra Pradesh and Karnataka (Ramachandrappa *et al*., 2004). Attention is now being paid to attain its potential in India for earning foreign exchange besides higher economic returns to the farmers. The lack of knowledge about the economic and nutritional importance of baby corn (*Zea mays* L.) coupled with non-availability of appropriate production technology are the major constraints for the popularization of baby corn among the farmers and consumers in Kashmir valley.

Sowing date is one of the major factors affecting the performance of the maize as it is essential for better utilization of available nutrients and moisture supplied to the crop. Depending on agro climatic conditions 3-4 crops of baby corn (*Zea mays* L.) can be taken in a year. Hence, better profit per unit area per season can be expected besides its high fodder value (Thavaprakaash *et al*., 2008). Fertilization also plays a crucial role in improving crop production, the presence of nutrient elements *viz.,* nitrogen, phosphorus and potassium in balanced from is essential (Mahmood *et al*., 1999). Among different nutrients provided to plants, nitrogen is the most important and limiting nutrient, associated with vigorous plant growth, deep green colour of leaves, yield of the crop and improving the quality parameters as well. Nitrogen is considered as a major nutrient for the crop to activate the metabolic activity within the plant and for transformation of energy, chlorophyll and protein synthesis. Phosphorus is also an essential plant nutrient. It is involved in root development, cell division, protein synthesis and is associated with a wide range of plant processes viz., photosynthesis, utilization of carbohydrates and growth and development. It is a constituent of ATP (Adenosine Triphosphate), ADP (Adenosine Diphosphate) and the most important substance in the life processes. Potassium is another important plant nutrient which plays an important role in various processes including enzyme activation, stomatal movement, protein synthesis, energy transfer, phloem transport and stress resistance. In order to popularize its cultivation among the farming community, it is essential to standardize its agro techniques not only for its potential yield but also for its quality. Therefore, there is need to work out optimum sowing date and fertility level for Baby corn under temperate conditions. Keeping in view the above facts, this study was carried out.

The experiment was conducted at Crop Research Farm of Division of Agronomy, Faculty of Agriculture, Sher-e- Kashmir University of Agricultural Sciences & Technology of Kashmir, Wadura, Sopore during *Kharif*, 2018. The site is situated between 34^{o} 21′ N and 74^{o} 23′ E at an altitude of 1590 meters above mean sea level. Climatically the experimental site is in mid to high altitude temperate zone characterized by hot summers and very cold winters. The average annual precipitation is 812 mm (average over past twenty years) and more than 80% of precipitation is received from western disturbances. The soil of the experimental plot was clay loam in texture, medium in organic carbon (0.98%), medium in available nitrogen (282 kg ha^{-1}), available phosphorus (23.2 kg ha^{-1}) and available potassium (215 kg ha^{-1}) with normal electrical conductivity (0.95 dS m^{-1}) and neutral pH (7.2).

The experiment comprised of two factors with four sowing dates *viz.,* 18th SMW (30th April - 6th May), 21st SMW (21st May – 27th May), 24th SMW (11th June – 17th June) and 27th SMW (2nd July – 8th July) as main plot treatments and four fertility levels *viz.,* Control treatment (F_0), 100:50:25 N: P_2O_5: K_2O kg ha^{-1} (F_1), 120: 60: 30 N: P_2O_5: K_2O kg ha^{-1} (F_2) and 140: 70: 35 N: P_2O_5: K_2O kg ha^{-1} (F_3) as sub-plot treatments laid out in split plot design with three replications. Total numbers of treatment combinations were 16 and the total numbers of treatment plots were 48. The gross plot size of each subplot was 14m^2 and the net plot size of each subplot was 9m^2.

Chemical analysis

The modified micro kjeldhal method, wet digestion molybdophosphoric acid method and flame emission spectrophotometry method were applied for estimation of nitrogen, phosphorus and potassium, respectively (Jackson, 1973). Vitamin C (ascorbic acid) was estimated by the method described by Ranganna (1986) using 2, 6 dichlorophenol indophenol as dye. Dye factor was first calculated by titrating 5 ml standard ascorbic acid plus 5 ml (3%) metaphosphoric acid against 2, 6, dichlorophenol indophenol till pink colour appeared and volume used noted.

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

The Vitamin C of cob sample with known weight was estimated by taking 10 ml volume of sample, which was then made up to 100 ml with 3% metaphosphoric acid and filtered. Then aliquot of 10 ml was taken in titration flask and titrated against dye 2, 6 Dichlorophenol indophenol till light pink colour appeared (which should persist for 15 seconds). Samples preserved by KMS (potassium metabisulphite) were analyzed after eliminating the interface of sulphur dioxide by using formaldehyde condensation procedure. Vitamin C was calculated using equation as:

$$\text{Vitamin C (mg/100g)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{vol.made up}}{\text{ml.of filtrate taken for estimation} \times \text{wt.of sample}} \times 100$$

The hand refractometer of range (0-32) ^{o}Brix (Erma Make Japan) was used to determine total soluble solids of fresh baby corn samples. The values were corrected at 20 ^{o}C (Ranganna, 1977). Protein content in baby corn and green fodder was determined by multiplying respective nitrogen content with a factor 6.25. Moisture content in the samples was determined by vacuum over method (A.O.A.C, 1984).

$$\text{Moisture content (\%)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{vol.made up}}{\text{ml.of filtrate taken for estimation} \times \text{wt.of sample}} \times 100$$

Economic analysis

Cost of cultivation was worked out on the basis of cost of inputs viz., cost of seed, FYM, nitrogen, phosphorus, potassium, tractorization, labour and other miscellaneous costs involved and expressed in ₹ ha^{-1}. Gross returns were calculated from the cost of produce i.e., cost baby corn and green fodder prevailing in the market at the time of experimentation and expressed in ₹ ha^{-1}. Net returns were calculated by subtracting cost of cultivation/ operating cost from the gross returns and expressed in ₹ ha^{-1}. Benefit cost ratio was determined by dividing net returns with cost of cultivation and expressed as benefit over 1 rupee invested.

The data obtained in respect of various observations were analyzed statistically. The Software package used for analysis of data was "OPSTAT", wherever the „F-test" was found significant at 5 per cent probability; critical difference values were used to compare the treatment means.

Effect of sowing dates

Results revealed that sowing dates had no significant effect on N, P and K content in baby corn and green fodder. However, 18th SMW sowing date recorded statistically higher values of N, P and K content in baby corn as well as green fodder as compared to other sowing dates whereas lower values of N, P and K content were recorded with 27th SMW sowing date (Table 1). The results of the experiment also revealed that quality parameters *viz.,* vitamin C content, total soluble sugars, protein content in baby corn and green fodder and moisture content in baby corn were not significantly influenced by sowing dates (Table 2). However statistically higher values of these parameters were recorded by early sowing of baby corn (18th SMW) which might be due to improved growth and higher temperature with delayed sowing which resulted in less assimilation of photosynthates. These results are in confirmation with Darby and Laver (2002) who concluded that delay in sowing resulted in lower quality forage. Mokhtarpour *et al.* (2008) also reported that delayed sowing resulted in lower quality of sweet corn. The results of Kara *et al.* (2012) also support the findings.

Effect of fertility levels

N, P and K content

From the present study it was found that N, P and K content (%) in baby corn and green fodder were significantly influenced by different fertility levels and among fertility levels F_3 fertility level (140:70:35 $N:P_2O_5:K_2O$ kg ha^{-1}) recorded significantly higher values of N, P and K content in baby corn as well as green fodder whereas the lowest values of N, P and K content were recorded with control treatment (F_0) as shown in Table 1. The increased concentration of N, P and K under higher fertility level might be due to their increased availability from soil. Moreover, higher photosynthetic activity in plant as evident from increase in biomass accumulation at successive growth stages and plant height reveals higher availability of metabolites from shoot to root. This might have promoted growth of roots as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial

Table 1. The N, P, and K content (%) of baby corn and green fodder as influenced by sowing dates and fertility levels

Treatment	N content (%)		P content (%)		K content (%)	
	Baby Corn	Green fodder	Baby corn	Green Fodder	Baby corn	Green fodder
MAIN PLOT						
Dates of sowing						
18th SMW (S_1)	1.68	0.84	0.47	0.24	0.76	1.25
21st SMW (S_2)	1.66	0.83	0.45	0.24	0.75	1.23
24th SMW (S_3)	1.64	0.81	0.44	0.22	0.74	1.22
27th SMW (S_4)	1.61	0.80	0.42	0.21	0.72	1.20
SEm$\pm$	0.03	0.01	0.01	0.01	0.01	0.02
CD ($p\leq0.05$)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT						
Fertility levels ($N:P_2O_5:K_2O$ kg ha^{-1})						
Control treatment (F_0)	1.19	0.67	0.31	0.17	0.57	1.03
100:50:25 (F_1)	1.55	0.77	0.42	0.21	0.72	1.20
120:60:30 (F_2)	1.85	0.88	0.49	0.25	0.80	1.28
140:70:35 (F_3)	2.01	0.96	0.56	0.29	0.88	1.38
SEm$\pm$	0.03	0.01	0.01	0.01	0.01	0.02
CD ($p\leq0.05$)	0.08	0.03	0.03	0.03	0.03	0.08

Table- 1: N, P & K
SMW = Standard meteorological week

Table 2. Quality of baby corn (*Zea mays* L.) as influenced by sowing dates and fertility levels

Treatment	Vitamin C (mg/100g) in baby corn	Total soluble sugar (%) in baby corn	Protein content (%)		Moistue content in baby corn (%)
			Baby corn	Green fodder	
MAIN PLOT					
Dates of sowing					
18th SMW (S_1)	11.53	10.36	10.53	5.28	89.30
21st SMW (S_2)	11.50	10.27	10.42	5.20	88.66
24th SMW (S_3)	11.41	10.25	10.26	5.12	88.33
27th SMW (S_4)	11.32	10.14	10.11	5.01	88.01
SEm$\pm$	0.08	0.05	0.21	0.09	0.24
CD ($p\leq0.05$)	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT					
Fertility levels ($N:P_2O_5:K_2O$ kg ha^{-1})					
Control treatment (F_0)	10.91	9.75	7.47	4.22	87.45
100:50:25 (F_1)	11.45	10.12	9.70	4.84	88.20
120:60:30 (F_2)	11.69	10.44	11.56	5.51	88.92
140:70:35 (F_3)	11.72	10.70	12.59	6.04	89.75
SEm$\pm$	0.07	0.07	0.18	0.07	0.18
CD ($p\leq0.05$)	0.21	0.22	0.52	0.21	0.53

SMW = Standard meteorological week

Table 3. Economics of baby corn (*Zea mays* L.) as influenced by various treatment combinations

Treatment combination	Total cost of Cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})			Net returns (₹ ha^{-1})	B:C ratio
		Baby corn	Green fodder	Total Gross returns		
S_1F_0	50650	79580	46684	126264	75650	1.49
S_1F_1	55224	108600	52377	160977	105753	1.91
S_1F_2	56145	138720	55134	193854	137709	2.45
$\mathbf{S_1F_3}$	57055	150360	57015	207015	149960	2.62
S_2F_0	50650	72320	45706	122970	72320	1.42
S_2F_1	55224	100100	49635	149735	94511	1.71
S_2F_2	56145	130400	53776	184176	128031	2.28
S_2F_3	57055	142560	55497	198497	141442	2.47
S_3F_0	50650	62340	43222	105562	54912	1.08
S_3F_1	55224	87700	46993	134693	79739	1.44
S_3F_2	56145	106460	49750	156210	100056	1.78
S_3F_3	57055	118740	52660	171400	114345	2.00
S_4F_0	50650	59460	42298	101758	51108	1.00
S_4F_1	55224	78880	44545	123425	68201	1.23
S_4F_2	56145	100480	46632	147112	90967	1.62
S_4F_3	57055	109200	48150	157350	100295	1.75

parts. The results of the investigation strongly support the findings of Bodake *et al.* (2006).

Vitamin C and protein content

The data shown in Table 2 indicated that Vitamin C (Ascorbic acid) content was found significantly higher with the application of F_3 fertility level (140: 70: 35 N: P_2O_5: K_2O kg ha^{-1}) compared to other fertility levels, whereas control treatment (F_0) recorded significantly lowest Vitamin C content in baby corn. Vitamin C which is also known as Ascorbic acid is a genetic factor but in most cases excess nitrogen application increases concentration of NO_3 in plants leading to check ascorbic acid formation. In present investigation, ascorbic acid formation was significant but at very marginal level. These results are well supported by the findings of Mozafar (1993). Total soluble sugar content in baby corn significantly increased with increasing fertility levels from F_0 (control treatment) to F_3 (140: 70:35 N: P_2O_5:K_2O kg ha^{-1}). The increase in total soluble sugar content of young cob with the application of higher fertility levels may be attributed to the better utilization of sufficiently available nutrients resulting in proper metabolic activities in plant and better synthesis process. The results are well supported by the observations made by Raja (2001), Showen *et al.* (2004) and Ramachandrappa *et al.* (2004). During the study it has been observed that protein content in baby corn and green fodder was significantly higher with the application of F_3 fertility level (140: 70:35 N: P_2O_5:K_2O kg ha^{-1}) over rest of the fertility levels and the lowest protein content was recorded with control treatment (F_0). Higher protein content with higher fertility levels might be attributed to the maximum nitrogen content accumulated and extended benefit with congenial bio-chemical relations at higher nitrogen levels as reported by Vishuddhan (2015). Earlier Jat (2006) had also reported increase in the protein content of baby corn with increased fertilizer application. Application of F_3 fertility level was significantly superior with respect to moisture content in baby corn compared to lower fertility levels. Increased moisture content of cob with increased fertility levels, in particularly that of nitrogen might have been associated with increased succulence of plants which ultimately resulted into higher moisture content of green cobs. The results are in close conformity with those of Das (1996), who also observed that increasing nitrogen application increases plant succulence which increases the moisture content.

Economics

Economics in terms of net returns and benefit cost ratio with respect to baby corn yield and green fodder yield was worked out for various treatment combinations (Table 3). It is evident from the data that highest net returns and benefit cost ratio of ₹149960 and 2.61, respectively was recorded by sowing baby corn in 18th SMW (S_1) with F_3 fertility level (140:70:35 N: P_2O_5: K_2O kg ha^{-1}) followed by 21st SMW sowing (S_2) with F_3 fertility level (140:70:35 N: P_2O_5: K_2O kg ha^{-1}) which recorded net returns and benefit cost ratio of ₹141442 and 2.47, respectively. The lowest net returns and benefit cost ratio of ₹51108 and 1.00 was recorded by sowing baby corn in 27th SMW (S_4) with F_0 fertility level (control treatment). The higher net returns and benefit cost ratio recorded by sowing baby corn in 18th SMW followed by 21st SMW sowing with F_3 fertility level could be attributed to higher baby corn and green fodder yield in these treatment combinations than others. The results are in accordance with the findings of Singh *et al.* (2015) and Nand (2015).

To conclude, the effect of sowing dates on the quality of baby corn was found non- significant, however early sowing date 18th SMW (30th April - 6th May) recorded statistically higher quality parameters compared to all other sowing dates. Fertility level F_3 recorded significantly higher quality parameters than all other fertility levels. Also higher net returns and benefit cost ratio were recorded by sowing baby corn in 18th SMW (S_1) applied with F_3 fertility level. Thus, it can be concluded that in order to obtain quality baby corn with higher economic returns, sowing in 18th SMW (30th April - 6th May) applied with F_3 fertility level (140:70:35 N: P_2O_5: K_2O kg ha^{-1}) is optimum for growing baby corn under temperate conditions.

Authors' contribution

Conceptualization of research work and designing of experiments (TAA, ZR, SR, SN, RAB, RHK); Execution of field/lab experiments and data collection (TAA, SJ, MSM); Analysis of data and interpretation (TAA, SM, TAB); Preparation of manuscript (TAA, TAS).

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