2. REVIEW OF LITERATURE

The global literature on various botanical aspects of Baby Corn such as genetic variability, correlations, path analysis, heritability and genetic advance, nutritional aspects along with general information were collected from the national and international publications as well as through internet. A brief account of the review of literature is presented here under.

1. Productive Genotypes:

Identification of productive genotypes of baby corn is essential to realize higher yield per ha and thereby getting higher returns for the farmers. Higher productivity helps farmer in getting more income and in elevating their standard of living. The literature on identification of productive genotypes of Baby Corn is presented below.

Parsanna et al. (1995) studied the potential of baby corn production in India, its quality traits and economic benefits and future prospects. They reported that baby corn genotypes should preferably have cylindrical and long ears, uniform ear size and properly developed ovule rows and that depending on agro-climatic conditions, 3-4 crops of baby corn can be taken in a year giving good profit. Regarding quality considerations they reported that varieties that give young ears of high quality are suitable for consumption and a low quality product is priced at only 30 percent of national prices and that texture, odour, colour, taste as well as the least decrease (per cent) in total soluble solids during canning are important.
Verma et al. (1998) reported from the studies conducted for 26 maize cultivars grown at densities of 1,00,000 or 1,25,000.

Kalloo and Kumar (1999) studied the baby corn production, its suitable varieties and post harvest technology and concluded it as a new area and research on post harvest management is not intensive. Baby corn is regarded as perishable product and hence precooling should be done within 1-2 hours after harvesting to avoid cob taste and quality degradation. VL-42 developed at Vivekananda Parvatiya Anusandhan Sansthan, Almora and MEH-114, a F1 hybrid developed by Mahyco Jalna have been recommended by Directorate of Maize Research, IARI, New Delhi for baby corn production.

Kasikranan et al (2001) studied the growth, yield, qualities and appropriate sizes of 8 baby corn cultivars for industrial uses grown on saline paleustults soil of northeast, Thailand. He reported the kernel yields for the tested cultivars were ranging from 2694 to 6600 kg/ha for SSW and Baby No. 1 respectively. The first best three cultivars could possibly be the baby corn no. 1, followed by SSW and KU no. 1 respectively.

Verma (2001) estimated baby corn production efficiency in 13 hybrids of maize and reported that the experimental hybrid (CM 128 x CM 129) x Tarun x (83-1-3-2) produced the highest baby maize over all the entries. This was significantly superior to all the checks except VL 42. The differences among the entries were also found to be significant for cob yield with husk, plant height, ear height, ear length and fodder yield.
Sharma et al. (2002) evaluated 8 hybrids, 2 early maturing composites and 4 composites of full-season maturity for their suitability in growing baby corn production during the kharif seasons of 1995, 1996 and 1997 at Ludhiana, Punjab, India and reported that early maturing hybrids and composites gave higher yields than late-maturing ones. The hybrid Parkash gave an average baby corn yield of 15.5 q/ha, which is 23.2% higher than the baby corn yield of 14.2 q/ha recorded for Kesri, which gave the highest baby corn yield among composites. Parkash also gave higher values for ears per plant (2.65), ear length (9.3 cm) and ear girth (1.45 cm) than the other genotypes. Parkash and Kesri gave green fodder yields of 211 and 185 q/ha, respectively.

Sain Dass et al. (2004) reported that the cultivation of baby corn is getting popular due to its delicious, high nutritive value and great potential for export. Baby corn cultivation is more remunerative than the grain maize in a given period of time. In the presence of assured market and infrastructure for processing, at least double income can be generated as compared to grain crop. Baby corn cultivation is a solution to problems emerged from continuous rice-wheat system like lowering of water table, Phalaris minor (weed) and degradation of soil health etc. Single cross early maturing hybrids, prolific in nature and having medium height are the preferred genotypes. Three to four baby corn crops can be taken up in North India and round the year in South India.

Nirmal de et al. (2005) evaluated 5 maize hybrids for baby corn production and reported that hybrids from Philippines IPB 929
recorded the highest husked cob yield of 6.84 t/ha with 20.44 per cent recovery of edible de-husked cobs. While both H-1 and H-2 (Pusa hybrids) recorded high edible de-husked cob yields of 22.15 and 21.70 per cent with husked cob yields of 6.42 and 6.73 t/ha, respectively. As early maturing and prolific cultivars are preferred for baby corn production, H-1 and H2 are more desirable.

Prodhan et al. (2007) evaluated nine varieties (hybrids, composites and elite lines) during kharif and rabi seasons of 2003-04 and 2004-05 in West Bengal, India, to identify high yielding varieties of baby corn. Two experimental single-cross hybrids, viz. S-18E x Golden baby and S-18E x Amber Pop, were found to be most suitable for baby corn production, showing optimum yield attributes, viz. husked yield, dehusked yield, standard yield, and fodder yield.

Prodhan et al. (2007) studied the yield and economic return in baby corn production and reported that baby corn cv. Early Composite showed an average grain yield of 15 q/ha and fodder yield of 300 q/ha. Net return, on average, was Rs. 6 000/ha in each crop, in each season.

Aekatasanawan et al. (2008) studied a new baby corn single-cross hybrid, KBSC 605 and reported that KBSC 605 gave unhusked ear weight of 6.556 kg/ha, husked ear weight of 1.175 kg/ha, good ear weight of 1.025 kg/ha, poor ear weight of 150 kg/ha, number of good ear weight of 26,052 ears/ha (90.61%) and number of poor ear weight of 2,701 ears/ha (9.39%) different from those of G-5414 by -10.72, 14.63, 22.39, -20.00, 9.80 and -43.97%, respectively. It possessed unhusked to husked ear weight ratio of 5.65 which was higher than
that of G-5414 (7.19). Moreover, it had 1.77 ears/plant, yellow ear with sharp tip, first harvesting date of 49.5 days, plant and ear heights of 190 and 104 cm, respectively.

Dass et al (2008) reported that additional income can be obtained by growing baby corn with other inter crops and many recipes and value added products can be made.

2. Correlation and variability
Correlation studies provide better understanding of the yield contributing characters which helps the plant breeder in selection of elite genotypes in the breeding material. A brief review of literature on this aspect is given below.

Viola et al. (2003) conducted correlation studies for yield and yield components of 24 elite lines of baby maize in Hyderabad, Andhra Pradesh, India during the rabi season of 1998. Number of days to silking, number of days to harvesting of fresh cobs, and cob length, height and weight, traits that were positively correlated, showed significant positive correlations with total cob yield.

Koner and Prodhan (2005) studied phenotypic and genotypic correlation for the fourteen different characters in baby corn between ear yield (husked yield, de-husked yield and standard yield) and other traits during the kharif season of 2002 in Kalyani, West Bengal, India. Correlation studies conducted for number of effective cobs per plant, ear length, ear height, plant height, TSS [total soluble solids], breaking pressure, cutting pressure, elasticity capacity, and fodder yield revealed that ear yield (husked yield, de-husked yield and standard yield) was positively and significantly (at 1% level)
correlated with ear length, ear diameter, and breaking pressure. Very high positive and significant correlation was observed between ear yield and ear length. Ear yield also showed a positive correlation with number of effective cobs per plant. Ear height, TSS and elasticity capacity which have showed highly significant and negative correlation with ear yield, were used to study the phenotypic and genotypic correlation.

Abirami et al. (2007) studied correlation and path coefficient analysis for 20 quantitative morphological and biochemical characters/traits in 40 maize genotypes belonging to the baby corn, sweet corn, popcorn, quality protein maize and grain maize types.

Tiwari and Verma (1999) studied genetic variability in 28 diverse genotypes of maize (baby corn) at Pantnagar in kharif 1997 and phenotypic and genotypic coefficients of variation, heritability (broad sense) and genetic advance were assessed. It was reported that differences between genotypes were highly significant for all 8 characters studied.

Rodrigues et al. (2003) evaluated plant height, ear height, number of ears per plot, weight, length, and diameter of husked and dehusked ears of 21 hybrids, 13 inbred lines, and one commercial control. Treatments comprised 2 plant densities (55 000 and 110 000 plants per ha). The analysis of variance showed that plant densities significantly affected all traits (P<0.05), except for plant height and weight of husked ears. The hybrid 27A x 31B had the best performance at 55 000 plants per ha, for husked and dehusked ears yield, while the 27A x 29B hybrid was better at 110 000 plants per ha,
taking the same traits into consideration. The hybrids did not overcome the husked and de-husked ears yield of inbred 27A at both plant densities.

Satyanarayana et al. (2005) studied the genetic variability in baby corn genotypes in Hyderabad, India to determine genetic variability, heritability and genetic advance for days to 50% silking, plant height, ear height, number of shoots per plant, shoot weight with husk, shoot weight without husk, shoot length, shoot girth, protein percentage, sugar content and yield per plant and reported that the phenotypic and genotypic coefficients of variation were high for yield followed by shoot weight without husk, number of shoots per plant, protein percentage, shoot girth, sugar content and shoot length. The environmental coefficient of variation was relatively high for shoot weight without husk followed by yield, sugar content and shoot girth.

Choudhuri and Prodhan (2007) studied 29 diverse sweet corn genotypes for genetic variation and character association in baby corn during rabi 2000 in West Bengal, India and reported that the genotypic and phenotypic coefficients of variation were high for ear yield, ear weight for first and second ear.

3. Path Coefficient Analysis:
Path coefficient analysis provide information about direct and indirect effects of independents variables on the dependent variables and thus helps in determining the yield contributing characters which is useful in indirect selection of superior genotypes.

Tiwari and Verma (1999) conducted correlation and path coefficient analysis on 8 yield-related traits in 28 baby corn genotypes
grown during kharif 1997 and reported that the genotypic correlation coefficients were in general, similar in direction to the phenotypic correlation coefficients, but higher in magnitude. Baby corn yield was positively correlated with the traits cob yield with husk, ear diameter and fodder yield, but negatively correlated with days to first silk emergence, plant height, ear height and ear length. Path coefficient analysis indicated that cob yield with husk followed by ear diameter made the greatest positive direct contribution to baby corn yield. Days to first silk emergence registered highly negative direct effects on yield.

Viola et al. (2003) conducted path coefficient analysis with maize and reported that early silking and harvesting of fresh cobs; greater plant height, cob length, cob weight, cob height, and number of cobs per plant; and lesser cob girth directly contributed to increased cob yield.

Abirami et al. (2007) reported that path analysis showed the weight of the cob contributed to the maximum direct effect to grain yield. It implied that selection for weight of the cob will be highly effective for the improvement of grain yield. Furthermore, the low residual factor indicated that the variables chosen in the present study were sufficient to explain grain yield.

4. Heritability and Genetic Advance:

Heritability and Genetic Advance are important selection parameters.

Tiwari and Verma (1999) found that heritability estimates were invariably moderate to high for all characters. High heritability with high genetic advance were observed for cob yield with husk and baby
corn yield. Hence, these traits are the most suitable for further improvement through selection.

Verma and Sarma (2001) found that heritability in broad sense, genetic advances and genetic advances as percentage of mean (both at 5 and 1% selection intensity) were high for baby maize yield, baby maize yield with husk, baby maize yield without husk, ear height, ear leaf area and plant height. Non-additive gene effects were found for days to 50 per cent tasselling, days to 50% silking, ear leaf length (cm), ear leaf breadth (cm), internode above first ear and total number of leaves.

Verma and Sarma (2001) studied genetic parameters for 12 quantitative characters in baby corn in the mid hills of Meghalaya and reported that significant differences were observed for all the characters. Baby maize yield (g/cm2), baby maize yield with husk (q/ha), baby maize yield without husk (q/ha), ear height (cm), ear leaf area (cm2) and plant height (cm) had considerable amount of variation as revealed by high phenotypic and genotypic coefficients of variation.

Viola et al. (2003) evaluated heritability and genetic advances for 14 traits in 24 elite baby corn lines grown in Rajendranagar, Hyderabad, Andhra Pradesh, India during the rabi season of 1998, and reported that Cob length, cob yield per plant, total sugar content and cob weight expressed high heritability coupled with high genetic advance as percentage of mean, indicating that additive gene action governed the expression of these traits. The number of days to 50% silking, number of days to harvesting, moisture percent at harvest, and number of days to 50% tasselling were characterized by high
heritability along with low genetic advance as percentage of mean. Moderate heritability with low to medium genetic advance as percentage of mean was recorded for number of cobs per plant, cob girth, cob height, plant height, number of seed rows per cob, and protein content.

Satyanarayana et al. (2005) reported that high heritability was registered for ear height followed by shoot length and days to 50% silking. Shoot length, shoot weight with husk, number of shoots per plant and protein percentage showed high heritability estimates along with high genotypic coefficient of variation estimates. Genetic advance as percent of mean was maximum for shoot length, number of shoots per plant, protein percentage, along with high heritability and genotypic coefficient of variation estimates.

Choudhuri and Prodhan (2007) observed high heritability with high genetic advance for ear weight of first and second ear, and breaking pressure for first and second ear, suggesting desired improvement in yield and quality through selection. High correlation value with direct and indirect effect showed that the number of effective cob, ear weight for first and second ear contributed most to yield.

5. Quality and nutritional aspects:

The quality and nutritional traits enhanced the utility of Baby Corn both for export purposes and domestic consumption. The available information on this aspect is presented below.

Yodpetch (1979) studied the nutritional composition of Baby corn and compared it with several other common vegetables cauliflower,
cabbage, tomato, egg plant and cucumber. Baby corn was reported to contain 89.1 per cent moisture, 0.21 per cent fat, 1.90 percent protein, 8.2 per cent carbohydrates and 0.60 per cent ash. One hundred gram of Baby corn was found to contain 28 mg of Ca, 86 mg of phosphorus, 0.10 mg of Iron, 64.00 IU of vitamin A, 0.05 mg of thiamine, 0.80 mg of riboflavin, 11 mg of ascorbic acid and 0.30 mg of niacin. Nutritional values were found to be comparable to other vegetable.

Yodpetch and Bautista (1983) reported that the optimum stage for harvesting young cob corn for canning is two days after silking and for table consumption purposes, three days after silking.

Bar Zur and Saadi (1990) reported that the prolific maize hybrids gave more harvested baby corn ears per plant in a single non-selective picking than the control cultivars. Total net yield of dehusked baby corn ears was greater in all hybrids tested when picked 3-4 days after silking. Total net yield of baby corn ears of the commercial sweetcorn and maize cultivars was higher than that of the prolific hybrids, but yield of marketable baby corn ears was significantly greater in the prolific maize hybrids. Several factors affecting harvest date were considered.

Trongpanich (1992) studied comparison of quality and preference of 13 baby corn varieties grown on the Kampang San campus of Kasetsart University for canning. Tests of quality and consumer preference after canning revealed that Thai Super sweet Composite 1 DMR was the best variety, having the highest preference scores for texture, odour, colour and taste as well as the least percentage decrease in total soluble solids during canning.
Sukanya (2000) studied nutritional qualities of baby corn and reported that considerable differences were observed among varieties for proteins, reducing sugars, ascorbic acid content and cooking quality. Variety "YBC-705" was found to be quite promising in protein and reducing sugar contents. "ITC-ZENECA" was high in ascorbic acid. "ITC-ZRNNECA" was found as the best variety for cooking whereas variety "C-6" was better for soup preparation.

Thakur and Jamwal (2001) concluded that the baby corn can be consumed in row form or used as an ingredient in various preparations like choupsey, soups, deep fried with meat or rice and fried with other vegetables, pickles etc.

Sain Dass et al. (2004) reported that the desirable length of baby corn is 7-10 cm with 1.0 to 1.4 cm diameter with regular row arrangement. The most preferred colour is generally creamish to very light yellow.

Singh, et al. (2006) studied the biochemistry of 10 genotypes/varieties of baby corn to work out their quality traits for table purposes. Significant variability was observed in different quality attributes which ranged from 17.72-23.19 per cent edible portion, 11.11-15.46 per cent dry matter, 2.99-3.84 per cent total sugars, 2.26-3.58 per cent reducing sugars, 0.076-0.903 per cent non-reducing sugars, 1.90-2.36 per cent protein, 45.38-80.16 mg per cent phosphorus, 8.59-11.66 mg per cent ascorbic acid. Among the genotypes/varieties of maize, R 2005 8 showed the best content of total and reducing sugars, dry matter, phosphorus and protein in its baby corn.
6. General Information:

Cheva-Isarakul and Paripattananont (1988) reported that Baby corn is a specialized vegetable and also one of the most promoted crops in Thailand. About 44000 t of fresh ears produced annually, of which only 20% was used as human food. The rest, mainly husk and silk, could be used as green fodder for livestock.

Pitakphanichkul (1989) emphasized that baby corn is on the way to exports. The demand for baby maize in both fresh and canned forms is high. Exports of canned baby maize from Thailand have increased rapidly since 1983. The crop was promoted under the Sixth National Economic and Social Development Plan (1987-91) as an industrial crop needed to be developed and supported. An estimated 30 per cent of baby maize is for domestic consumption and fresh exports and the remainder 70 per cent is canned. Major markets for Thai exported fresh baby maize include Hong Kong, Singapore, Malaysia, Canada and the GFR which all together absorb some 3-4 t per day.

Zhao (1991) found that the maize cultivar Ji Te 3 was suitable for producing ears of the baby corn type for cooking or canning.

Kotch (1995) studied the factors affecting the production of baby corn during 1988-89 in 11 maize cultivars and assessed the effects of plant spacing (10 or 20 cm spacing) and sowing date (May to July) on yield. Cultivars were also evaluated for organoleptic qualities such as colour, taste and appearance. Cultivar was the most important factor determining yield, cv. Robust 41-10 producing consistently high yields in both years. All cultivars produced higher yields at the 10 cm plant spacing, while sowing dates earlier than 19 June had no
significant effects on yield. Maize sown in July was unsuitable for baby corn production because late season growing conditions (reduced moisture, high temperatures) resulted in poor seed germination and growth.

Kumar and Kalloo (2000) studied attributes that make maize genotypes suitable for baby corn production are described, including early maturity, prolificacy, synchronized ear emergence and yellow kernel.

Verma and Sarma (2001) studied the phenotypic stability of five maize genotypes used as baby corn over three environments for yield and yield attributing characters and concluded that genotypes RCM1-1, MLY and RCM 1-3 were found to be most suitable for baby corn yield for their average performance and responsiveness along with stability for midhills of Meghalaya.

Carvalho et al. (2003) studied different cropping environments for the effects of different sowing dates with or without detasseling on 8 maize cultivars for baby corn production at Lavras Federal University, Gerais, Brazil and reported that the effects of plant detasseling varied with the cultivar and sowing date. The significant cultivar x sowing date interaction for all the characters indicate that the performance of the cultivars was significantly affected by the sowing date. DKB 929 showed better performance for husk and baby corn weights for all three sowing dates.

Almeida et al. (2005) evaluated 10 maize cultivars for the yield of baby maize, green ear and dry grains in Mossoro, Rio Grande do Norte, Brazil and reported that baby maize yield (178571 plants ha-1)
in one of the experiments. The another experiment (50 000 plants ha-1) evaluated green ear and dry grain yields. DKB 350 and AG 8080 were superior in terms of the number and weight of marketable un-husked, and husked baby maize ears. DKB 435 and AG 8080 recorded the greatest number and weight of marketable, un-husked, and husked ears. No differences were observed between cultivars for grain yield.

Thavaprakaash et al. (2006) reported on various aspects of baby corn giving detailed account of botany, cultivation and economics, origin, geographical distribution, morphology, germination, growth, climate and soil requirements, cultivation practices, field preparation, sowing, nutrient management, water management, weed management, cropping systems, plant growth regulator application, plant protection measures, detasselling and harvesting, organic farming, post-harvest handling, and marketing.

Silva et al. (2006) studied the green ear yield and grain yield of maize after harvest of the first ear as baby corn in Minas, Gerais, Brazil and reported that removing the first female inflorescence induces maize to produce others making it possible to produce several baby corn ears. Marketable green ears yield or grain yield produced without removing the first inflorescence were superior to the green ear yield or grain yield produced after the removal of the first inflorescence harvested as baby corn.

It is obvious from the literature cited above that the reports available on the genetic variability, correlations, path analysis, heritability and genetic advance, nutritional aspect are limited and very few Indian references are available. Hence, the present
investigation on "Identification of suitable genotypes of baby corn for productivity and quality traits" will be useful in the identification of productive and superior quality genotypes for baby corn for cultivation.

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