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A New Single Cross Pop Corn Hybrid IHPC-1203 for *Kharif* Cultivation in North West Peninsular Zone, North East Peninsular Zone and Peninsular Zone

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A B S T R A C T

A new Single cross Pop corn hybrid IHPC-1203 was developed at Main Maize Research Station, AAU, Godhra, Gujarat and it was evaluated across the locations all over India during *Kharif* 2016 to *Kharif* 2018. This hybrid involves two diversified inbred parents*i.e*IGPF-21 as female and IGPM-23 as male parent. It yielded on an average 38.76 Q/ha popcorn yield and found 24.8 % superior in yield over the check VL Amber popcorn in the North West Peninsular Zone (NWPZ). It yielded on an average 32.94 Q/ha popcorn yield and it is found 30.6 % superior in yield over the check VL Amber popcorn in North East Peninsular Zone (NEPZ) and it yielded on an average 49.22 Q/ha popcorn yield and found 26.1 % superior in yield over the check VL Amber popcorn in the Peninsular Zone (PZ). The quality point of view, this hybrid having high popping (92 %) and popping volume (213 ml/ cm3) and it contains starch 75.55 (%), β- carotene 6.193 (ppm) and tryptophan 0.104 (%). This hybrid shows degree of resistant to major diseases in artificial condition in all the zone. It exhibited moderate resistant against MLB and charcoal rot in NWPZ. Moderate resistance against C. Rot, P. rust and TLB diseases in PZ. Same way this hybrid exhibited varying degree of resistance to stem borer *Chillopartellus* in artificial condition. It exhibited moderate resistance against *Chillopartellus* in all three zone. Based on the overall performance and superiority over national check VL Amber Pop corn, it is identified and recommended to release for *Kharif* cultivation in the NEPZ, NWPZ and PZ in India.

Introduction

Maize is popularly known as “Corn” is most versatile emerging cash crops having wider adaptability under varied climatic condition. It is called queen of cereal globally. In India, maize is third most important cereal after wheat and rice. The maize is grown through out the year. Maize is being consumed both food and fodder crop and also required by various industries in India. In food category, specialties corn likes baby corn, sweet corn and popcorn are of great importance in value addition industries. Popcorn consumption

may have boomed over the past decade, especially in multiplex cinemas, malls and food courts across metros and Tier-II cities as well as people conscious regarding health. Popcorn is popular and is consumed by people of all ages throughout the world (Park and Maga, 2001; Karababa, 2006; Ertas *et al.*, 2009). The common health benefits of popcorn are such that it improves digestive health, is rich in antioxidants, helps in metabolism and provides energy, reduces depression, supports healthy bone function, controls blood sugar level, combats tumour cells, reduces craving for food and prevents aging. A popcorn kernel's small and strong hull contains the seed's hard, starchy endosperm with 14–20% moisture, which turns to steam as the kernel is heated. Pressure from the steam continues to build until the hull ruptures, allowing the kernel to forcefully expand from 20 to 50 times its original size and finally call as popcorn. The quality of popcorn is expressed as popped volume, shape of the popped kernels, tenderness and flavor. The popped volume is perhaps most important because the commercial buyers buy on weight basis but sell the popped popcorn by volume.

Pop corn hybrid is not available in Gujarat till date. Thus the produce has less uniformity, which in turn affects their market acceptance, particularly in international market. In India, most of the hybrids available from private sector and some from public sector as well. Therefore, there is a need to develop popcorn hybrids for Gujarat and some part of country. Looking to the research reviews, Dofing *et al.*, (2015) reported that there were significant differences among hybrid cultivars in popping volume, and that hybrid genotypes provided higher values than open-pollinated cultivars. In *rabi*, some of the farmers are growing only Amber popcorn variety (composite) resulted in low productivity. There is usually a negative relationship between the popping volume and overall seed yield. Higher popping volumes were recorded for low- or medium-yielding cultivars whereas high-yielding cultivars had lower popping volumes (Pajic 2000). Consumers desire good popping popcorn with low numbers of unpopped kernels, and tender, palatable, delicious flakes having less seed coat remaining. On the other hand, growers look for high yielding capacity, plant stability, and good resistance to diseases and pests (Babic and Pajic 2012). Hence, there is a need to release medium maturity and high yielding popcorn hybrid to replace the composite/open pollinated varieties to enhance yield and productivity of popcorn. Therefore, this single cross popcorn hybrid IHPC-1203 was developed and tested in AICRP system across all over India and it was identified for release in three zones comprising the states of NWPZ (North West Plain Zone-Punjab, Haryana, Delhi, Uttarakhand, Uttar Pradesh), NEPZ (North East Plain Zone-Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region), West Bengal) and PZ (Peninsular zone- Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu) because of its higher yield and good popping quality.

Materials and Methods

A new single cross Pop corn hybrid, IHPC-1203 developed involving two inbred lines, IGPF-21 and IGPM-23 in *rabi* 2015-16 at Main Maize Research Station, Anand Agricultural University, Godhra, Gujarat. It is medium maturing yellow hybrid having orange flint grains. It matures within 85-90 days in *Kharif* season. The quality point of view, this hybrid contains 75.55 % starch, 10.51% protein, 4.41% oil, and 6.193 β-carotene. This hybrid was tested in AICRP system and in *Kharif* season trials were conducted at All Indian level across all the four zones comes under AICRP on maize network *i.e.* NWEZ, NEPZ, PZ and CWZ.

The trials were conducted in Randomized Block Design with three replications by keeping 60 x 20 cm sowing distance. The multilocation evaluation of hybrid carried out during *Kharif* -2016 to *Kharif*-2018. The randomized block design was used to conduct experiments by taking 6 rows of 4 meter length and 60 x 20 cm plot size under *Kharif* conditions. All recommended agronomical cultivation practices for agro climatic zones were practiced to raise crop for observing traits. The standard methods laid by Indian Institute of Maize Research, Ludhiana were adapted to record observations and statistical analysis. Data on grain yield, days to tasselling, height of plant, grain moisture rate (content) in harvest, percentage of unpopped kernel and popping volume were measured for genotypes. Data were taken on tasselling time (days from planting to tasselling of 50 % of plants), grain yield (kg ha-1), plant height (cm), grain moisture in harvest (%), were estimated from a sample of all plants in two rows of every plot. Grain yield was corrected for a standard humidity of 14.5 and was transformed into kg ha-1 (Arnhold *et al.*, 2009). After harvest, for each replication, genotypes samples were dried by natural convection at room temperature to 14% moisture. Among all the characters studied, three characters viz., moisture%, final plant stand and cob yield per plot were taken. Standard statistical software RBD-Covariance using these three characters was used get the final yield per hectare by ANCOVA (CD value, CV% and SEM+ values).

Popping tests were performed by using a hot air popping machine (Arçelik, ARK77 MP, 230 V, 1200W). The moisture content of samples was 14±0.5% before popping. Before and after popping, the number of kernels for each sample was counted. Popped samples were poured into a 2000 mL plastic graduated cylinder, and volume recorded (Troyer, 2001; Ceylan and Karababa, 2004; Gökmen, 2004; Sakin *et al.*, 2005; Soylu and Tekkanat, 2007). The traits associated with expansion volume are the number of unpopped kernels and grain moisture content at the time of popping (Singh *et al.*, 2007).

Expansion volume = [Total popped volume (cm3)] / [Original sample weight (g)]

Percentage of unpopped kernel = (Number of total unpopped kernels/Original number of kernels) X 100

Biochemical analysis of the hybrid was conducted at the Department of Biochemistry, B A College of Agriculture, Anand Agricultural University, Anand by using the standard protocol.

Results and Discussion

A new Single cross Pop corn hybrid IHPC-1203 was evaluated across the locations all over India in four different zones comprising 23 states during *Kharif* 2016 to *Kharif 2018*. The yield performance of hybrid IHPC-1203 across the different zones are shown in the table 1. It shows that, the hybrid yielded on an average 38.76 Q/ha popcorn yield and found 24.8 % superior in yield over the national check, VL Amber popcorn in the North West Peninsular Zone (NWPZ). It yielded on an average 32.94 Q/ha popcorn yield and it is found 30.6 % superior in yield over the national check, VL Amber popcorn in North East Peninsular Zone (NEPZ) and it yielded on an average 49.22 Q/ha popcorn yield and found 26.1 % superior in yield over the national check, VL Amber popcorn in the Peninsular Zone (PZ).As per the data presented in table 2, the hybrid comes into silking 50.6 to 53.0 days across the zones in *Kharif* season which is preferable to farmers of the region as it takes 85-90 days to mature and harvest at proper stage.

Table.1 Summary yield data of Coordinated Varietal Trials (Pop corn yield weight)

Zones		NWPZ			NEPZ			PZ		
	Year of testing	**No. of trials/ location**	**IHPC-1203**	**VL Amber popcorn**	**No. of trials/ location**	**IHPC-1203**	**VL Amber popcorn**	**No. of trials/ location**	**IHPC-1203**	**VL Amber popcorn**
Mean yield Q/ha) Zonal Across zones	*Kharif*-2016	25	41.03	31.04	25	36.97	24.82	25	46.87	30.82
	Kharif-2017	23	39.80	30.47	23	32.94	26.13	23	48.75	37.01
	Kharif-2018	25	35.44	31.66	25	28.92	24.74	25	52.03	49.24
Weighted Mean			**38.76**	**31.06**		**32.94**	**25.23**		**49.22**	**39.02**
Percentage increase or decrease over the checks and qualifying varieties	*Kharif*-2016	25		32.2	25		49.0	25		52.1
	Kharif-2017	23		30.6	23		26.0	23		31.7
	Kharif-2018	25		11.9	25		16.9	25		5.7
Weighted Mean				24.8			30.6			26.12
Frequency in the top three group (pooled for three years)			2/3	0/3		2/3	0/3		2/3	0/3

Table.2 Data on other important characters

Characters	Item	NWPZ		NEPZ		PZ	
		IHPC-1203	**National checks 1 (VL Amber popcorn)**	**IHPC-1203**	**National checks 1 (VL Amber popcorn)**	**IHPC-1203**	**National checks 1 (VL Amber popcorn)**
Plant height	*Kharif*-2016	191	161	159	143	186	164
	Kharif-2017	199	167	164	145	189	175
	Kharif-2018	195	174	169	155	160	147
Average		**195**	**167**	**164**	**148**	**178**	**162**
Ear height	*Kharif*-2016	92	70	69	55	90	76
	Kharif-2017	106	93	76	68	96	87
	Kharif-2018	97	85	76	71	78	70
Average		**98**	**83**	**74**	**65**	**88**	**78**
Days to 50 % silking	*Kharif*-2016	50	51	51	53	54	54
	Kharif-2017	51	51	50	52	52	53
	Kharif-2018	53	53	51	51	53	53
Average		**51.3**	**51.7**	**50.6**	**52.0**	**53.0**	**53.3**

Table.3 Quality parameters of IGPHC-1202 (IHPC-1203) along with check

Year	IHPC-1203	Amber popcorn	IHPC-1203	Amber popcorn
	Popping (%)		Popping volume (ml/cm^3)	
***Rabi* 2015-16**	92	76	200	130
***Rabi* 2016-17**	96	90	250	200
***Rabi* 2017-18**	89	80	190	170
Average	92	82	213	167

Table.4 Biochemical status in seed of propose hybrid and check

Traits	IHPC-1203	Amber Popcorn	Traits	IHPC-1203	Amber Popcorn
Moisture (%)	6.05	4.73	Flavanoid (%)	0.094	0.098
Starch (%)	75.55	70.86	Lysine (%)	0.293	0.299
Sugar (%)	2.511	3.304	Tryptophan (%)	0.104	0.091
Reducing Sugar (%)	0.101	0.176	Fiber (%)	2.619	2.778
Phenol (%)	0.152	0.166	β Carotene (ppm)	6.193	8.022

Table.5a Reaction to major diseases (NWPZ)

Name of proposed hybrid : IHPC-1203 (Godhra Hybrid Popcorn-1203)				
Disease Name	**Condition of screening**	**Season**	**IHPC-1203**	**National checks 1 (VL Amber popcorn)**
MLB	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	MR	MR
		Kharif-2017	MS	MS
		Kharif-2018	MS	MS
Charcol rot	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	MR	S
		Kharif-2017	MR	MS
		Kharif-2018	MS	S
BLSB	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	S	S
		Kharif-2017	MS	MS
		Kharif-2018	MS	MS
TLB	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-

Table.5b Reaction to major diseases (NEPZ)

Disease Name	Condition of screening	Season	IHPC-1203	National checks 1 (VL Amber popcorn)
MLB	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	-	-
		Kharif-2017	MS	S
		Kharif-2018	MS	MS
CLS	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
BLSB	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
TLB	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	S	S
		Kharif-2017	MS	MS
		Kharif-2018	-	-

Table.5c Reaction to major diseases (PZ)

Disease Name	Condition of screening	Season	IHPC-1203	National checks 1 (VL Amber popcorn)
P.rust	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	MR	MR
C.ROT	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	MR	S
		Kharif-2017	MR	MS
		Kharif-2018	-	-
TLB	**Natural**	*Kharif*-2016	-	-
		Kharif-2017	-	-
		Kharif-2018	-	-
	Artificial	*Kharif*-2016	S	S
		Kharif-2017	-	-
		Kharif-2018	MR	MS

Table.6 Reaction to Insects-Pests

			NWPZ		NEPZ		PZ	
Insect Name		**Item**	**IHPC-1203**	**National checks 1 (VL Amber popcorn)**	**IHPC-1203**	**National checks 1 (VL Amber popcorn)**	**IHPC -1203**	**National checks 1 (VL Amber popcorn)**
ChilloPartellus	**Natural**	*Kharif*-2016	R	R	R	MR	R	MR
		Kharif-2017	MR	MR	MR	S	S	MR
		Kharif-2018	MR	MR	MR	MR	MR	S

Scale:1-1.9: Highly Resistant ,2.0-3.0: Resistant , 3.1-5.0 : Moderate Resistant, 5.1-7.0: Susceptible, >7.1 : Highly Susceptible

R : Resistant, MR: Moderate resistant, S: Susceptible, MS: Moderate Susceptible

In addition of grain yield, popping % and popping volume is the most important factor for the daily use, table and industrial purpose. Looking to the analysis and data in table 3, this hybrid is expressing high popping (92%) and popping volume (213 cm3) which is higher than amber popcorn. In context to its biochemical features and the data showed in table 4, the small sized orange flint grain exhibited good quality of nutritive factors like 75.55 % starch, 10.51% protein, 4.41 oil and 6.19 ppm β- carotene in seed. Yield and quality of pop corn may varied from variety to variety was observed by Mehmet Ali Sakin *et al.,* (2005) while studying the effect of pop corn cultivars. The nutritional composition of popcorn may vary with varieties, the environment and the manner in which it is prepared. However this has not been reported in the literature. The nutrients reported in Nigerian popcorn hybrids include 64% carbohydrate, 8.7% protein and 8.8% fat (Ademiluyi and Oduola, 2011). Microwave popping and hot air popping are therefore the preferred methods for the health conscious, since they provide an option of popping without fat. This hybrid shows varying degree of resistant to major diseases in artificial condition in all the zone. It exhibited moderate resistant against MLB and charcoal rot in NWPZ (Table 5a). Moderate resistance against C. Rot, P. rust and TLB diseases in PZ (Table 5c). Same way this hybrid exhibited varying degree of resistance to stem borer *Chillopartellus* in natural condition. It exhibited moderate resistance against *Chillopartellus* in all three zone (Table 6).

In conclusion the high yielding, Popcorn hybrid IHPC-1203 is identified for *Kharif* cultivation in the NWPZ (North West Plain Zone-Punjab, Haryana, Delhi, Uttarakhand, Uttar Pradesh), NEPZ (North East Plain Zone-Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region), West Bengal) and PZ (Peninsular zone-Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu). It produces pop corn yield of 3876 kg/ha, 3294 kg/ha and 49.22 kg/ha in NWPZ, NEPZ and PZ, respectively. It is a medium maturing, orange flint grains and havinghigh popping (92%) and popping volume (213 ml/cm^3) and it is similar in grain colour and texture as of popular local cultivars. The produce of it will fetch high price from the market and popping industry. As looking to the biochemical parameters the produce of hybrid is of high quality, so it will fetch high price from the market also. So, after cultivation in the different states, it could improve the

livelihood of the farmers. Popping volume, which is the most important quality character, was significantly higher in this hybrid than the check cultivars, Therefore, the hybrid cultivars should be grown instead of open-pollinated cultivars under optimum environmental conditions, because quality is as important as yield in popcorn.

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