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PGR NOTE

Larnoo Purple: A High Yielding, Early Maturing, Cold Tolerant Maize Line with High Carotenoid and Protein Content

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The present study pertains to the development of new maize line Larnoo Purple possessing high yield, early maturity, disease resistance and cold tolerance. Larnoo Purple revealed an average yield performance of 5.6 t ha^{-1} in station trials that is almost similar to the commercial check variety Shalimar Maize Composite-3. The genotype revealed complete resistance to *Turcicum* leaf blight, common rust and stem borers. However for cutworms, the variety was found to be moderately resistant. Larnoo Purple due to its tolerance for drought and low temperature stresses, fits well under high altitude rainfed conditions of Jammu and Kashmir. The cob of Larnoo Purple is conical, semi-flint and purple in colour, possessing good grain characteristics. Biochemical profiling of Larnoo Purple revealed that the genotype contains elevated levels of carotenoids, protein, starch and oil over the commercial check variety Shalimar Maize Composite-3. Larnoo Purple has potential to improve the socio-economic conditions of small and marginal farmers in high altitude rainfed temperate agro-ecologies, besides improving their health and nutritional status.

Key Words: Early maturity, High carotenoid, High yield, Larnoo Purple, Protein content, Stress tolerance

Maize (*Zea mays* L.) is the third most important cereal crop in India grown over an area of about 9.1 million hectares with the production of around 22.75 million tons. In the state of Jammu and Kashmir, maize is the most important crop in terms of acreage and is being cultivated over an area of 0.31 million hectares with the annual production of 0.48 million tons (GoI, 2017). Kashmir valley (longitude 73.0-74.2°E and latitude 33-34°N) is agro-climatically a typical temperate region, where maize is being cultivated at an altitude of 1850-2500 m above mean sea level (amsl). Maize in Jammu and Kashmir is grown as *Kharif* season crop, mostly on marginal lands of hilly terrains and about 85% of the cropped area is rainfed. The average productivity of this crop in the state is significantly low (1.2 t ha^{-1}) when compared to the national productivity of 2.5 tons ha^{-1} (GoI, 2017). Cultivation of low yielding local land races followed by frequent incidence of various biotic and abiotic stresses act as the main limiting factors for maize production in the valley. Growing of high yielding stress tolerant varieties can serve as the most coherent approach to ensure high maize productivity under these conditions.

In addition to high yield, the demand for quality maize is continuously increasing primarily due to diversification in food habits, change in consumer preferences and improvement in standard of living. This entails the incorporation of desirable quality traits in maize, as the most important objective, next only to yield enhancement. Nowadays, pigmented maize has received increased attention from a nutraceutical quality perspective as it contains several bioactive phytochemicals such as carotenoids, tocopherols, phytic acid and phenolic compounds (Ibrahim and Juvik, 2009; Hu and Xu, 2011). Although these compounds are considered to be non-nutritive, the interest in their antioxidant and bioactive properties has been increased due to their potential health benefits (Okarter and Liu, 2010).

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Larnoo Purple is an early maturing, disease resistant, cold tolerant selection of maize possessing high carotenoid, protein and oil content. It has been developed by mass selection from early maturing, purple maize genotypes collected from higher altitudes (2000 to 2500 m amsl) of Kashmir valley. Initially, 200 plants were selected and equal quantity of seeds from these plants was composited and allowed to random mate in isolation. This was followed by three cycles of recombination and selection (half-sib) for high yield, early maturity, quality protein, disease resistance and cold tolerance in the target environment. The selected genotype (Larnoo Purple) was evaluated for yield and other agro-morphological attributes during the *Kharif* seasons of 2015-17 under station trials at Mountain Crop Research Station Larnoo (SKUAST-K) situated at an altitude of 2290 m amsl. The genotype was evaluated under various agronomic management practices *viz*., different fertilizer doses and spacing levels to devise the most effective combination for optimum yield returns. The genotype was also screened for resistance to prevailing diseases and pests following the Standard Evaluation System of CIMMYT (Mugo *et al*., 2001; Shekhar and Kumar, 2012). The quality analysis for protein, tryptophan, carotenoids, sugar, starch and oil was carried out at biochemistry laboratory of ICAR- Indian Institute of Maize Research (IIMR, Ludhiana). The maize line has been submitted to the National Genebank at ICAR-National Bureau of Plant genetic Resources under the accession number IC624629.

Larnoo Purple revealed an average yield performance of 5.6 t ha^{-1} in station trials that is almost similar to the commercial check variety Shalimar Maize Composite-3 (Table 1). The results of agronomic manipulations for the test genotype showed maximum yield potential at the spacing of 60 × 20 cm with 100% recommended fertilizer dose (60, 40 and 20 kg of N, P_2O_5 and K_2O ha^{-1}) along with the application of 15 t ha^{-1}of FYM. Similarly, maximum response to yield was observed when the crop was sown in between second to last week of April at the seed rate of 20 kg ha^{-1} for line sowing and 30 kg ha^{-1} for broadcasting. Moreover, biotic stresses like *Turcicum* leaf blight, common rust and insect pests (*viz*., cutworms and stem borers) are the major threats to maize cultivation under high altitude conditions of Kashmir valley. Larnoo Purple has shown complete resistance to *Turcicum* leaf blight (TLB), common rust and stem borers. However for cutworms, the variety was found to be moderately resistant (Table 2). Among the abiotic stresses, the major challenges for maize crop under temperate conditions of Kashmir valley are recurrent occurrence of droughts and cold spells. These abiotic stresses have devastating effects especially at sowing and flowering stages. Larnoo purple has tolerance to drought and low temperature stresses, and thus fits well under high altitude rainfed conditions of Jammu and Kashmir.

The cob of Larnoo Purple is conical, semi-flint and purple in colour, possessing good grain characteristics (Fig. 1). The plant height is about 235 cm with cob placement at around 105 cm from the ground level. The genotype matures within 130 to 135 days at an altitude range of 1800-2000 m amsl and 145-150 days at 2000-2250 m amsl. Biochemical profiling of Larnoo Purple, carried out at ICAR-IIMR Ludhiana, revealed that the genotype contains elevated levels of carotenoids, protein, sugar, starch and oil over the commercial check variety Shalimar Maize Composite-3 (Table 2). High-performance liquid chromatography (HPLC) was used for the estimation of carotenoids, sugar and starch. Protein content was determined using micro-kjeldal method and oil content was appraised using Nuclear magnetic resonance spectrometer (NMR).

To summarise, Larnoo Purple possesses high yield potential, early maturity, resistance to biotic and abiotic stresses along with elevated levels of carotenoid,

Table 1. Grain yield performance of Larnoo Purple in station trials over years.

Cultivar	Grain yield (t ha^{-1})		
	2015	2016	Average
Larnoo Purple	5.92	5.28	5.60*
Shalimar Maize Composite-3 (check)	6.17	5.55	5.86*
Larnoo Local	3.40	3.72	3.56

'*' indicates that the grain yield of Larnoo Purple is significantly higher over Larnoo Local and is at par with the check variety (SMC-3) at level p = 0.05.

Table 2. Disease and pest resistace reaction of Larnoo Purple over the check variety.

Cultivar	Disease Intensity		Pest infestation		
	TLB	common rust	cutworms	borers	Aphids
Larnoo Purple	10.3 (1)	9.4 (1)	13.4 (2)	7.0 (1)	5.8 (1)
Shalimar Maize Composite-3 (check)	15.6 (2)	18.0 (2)	27.3 (3)	9.7 (1)	7.2 (1)

Figures in parentheses indicate disease/pest scores. 1-5 scale was used for scoring the disease and pest reaction.
1= Resistant; 2= Moderately resistant; 3= Moderately susceptible; 4= Susceptible; 5= Highly susceptible

Table 3. Grain quality features (biochemical profile) of Larnoo Purple over the check variety.

Variety	Protein (%)	Tryptophan in protein (%)	Total carotenoids (µg/g)	Sugar (%)	Starch (%)	Oil (%)
Larnoo Purple	9.12	0.63	29.6	3.75	71.02	5.04
Shalimar Maize Composite-3 (check)	8.06	0.66	6.4	4.48	64.12	4.78
% improvement over the check	13*	-	362.5*	-	10.76*	6.06*

'*' indicates significant improvement in the trait at level, p = 0.05.

Fig. 1. Morphological features of Larnoo Purple

protein and oil content. The genotype can thus be used as a parent in breeding programmes for accumulation of favourable genes in elite cultivars (Harjes *et al.*, 2008). The development of high yielding maize genotypes possessing early maturity, cold tolerance and resistance to various biotic stresses in addition to high content of micronutrients can improve the socio-economic conditions of small and marginal farmers in high altitude rainfed temperate agro-ecologies, besides improving their health and nutritional status.

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