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Kwanu Local – A High Yielding Traditional Maize Cultivar of Jaunsar Tribal Region of Uttarakhand and a Promising Genetic Resource for Maize Improvement

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Globally maize is the second most important crop in terms of acreage where as in India it ranks third after wheat and rice. Maize productivity has been breaking unprecedented barriers owing chiefly to wide scale cultivation of high yielding hybrids. Sustaining high yields of hybrids necessitates continued efforts for creation of novel gene assemblages and/or discovery of such naturally existing constellations. Traditional local cultivars are an important source of the latter. Kwanu Local is an example of such a traditional cultivar that contributes significantly towards sustaining food, fodder and fuel requirement of Jaunsari tribal community of Kwanu cluster in Dehradun district of Uttarakhand. It is a tall, high yielding, medium duration, semi-dent yellow bold-grained cultivar and owes its characteristic present form to multiple infusions from diverse populations that have taken place over the long history of its cultivation in the region. Its cultivation over a vast contiguous expanse and the selection practices followed by the farming community ensure maintenance of high heterozygosity in the population, assuring sustained high yields. The cultivar possesses many desirable features that make it a potential genetic resource for a variety of traits of agronomic importance (cob length, cob girth, number of kernels/row and kernel size). Its use for increasing kernel size has been well demonstrated. Kernel size in the backcross progenies involving inbreds VQL 1 (255 g) and V 400 (215 g) as recipients and Kwanu Local (343 g) as donor exhibited kernel size range of 260-293 g (VQL 1 x Kwanu Local) and 228-245 g (V 400 x Kwanu Local), showing increase of 6-14 and 2-15%, respectively, in the two crosses. With its local adaptability and high yield coupled with other desirable traits, Kwanu Local holds potential as a promising genetic resource for maize improvement.

Keywords: Genetic resource, Jaunsar, Kernel size, Kwanu Local, Traditional cultivar

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Maize is the second most important cereal crop in the world in terms of acreage, however, in terms of overall value it is one of the most important cereal crops of the world. Maize is the third most grown cereal crop within India after paddy and wheat. India contributes around 2% of the global production with a quantum of 26 million MT in 2016-17[1]. However, the national productivity of maize (2.6 tons/ha) is considerably lower than the global standards (5.6 tons/ha) and therefore, there lies immense scope for improvement in maize productivity in the country. In India, hybrid maize is grown in about 65-70% of total maize acreage and most of it accounts for feed and industrial grade maize, whereas food grade maize is produced using traditional cultivars (OPVs)[1].

In Uttarakhand, maize is cultivated in about 22 thousand ha including both hills and plains. The crop is grown for food, feed and fodder and forms an integral constituent of all major cropping systems prevalent in the state. Sixty-three per cent of total maize area in the state lies in the hills with the remaining 37% being in the plains. Dehradun district accounts for over one-third of the total maize area in the state[2]. Maize growing area in the hills is predominantly occupied by local cultivars, with each cultivar having developed its characteristic features through natural and human selection during the long course of their cultivation. Local maize cultivars/landraces of Uttarakhand (Almora, Chamoli and Dehradun districts particularly) exhibit rich diversity[3].

Jaunsar tribal area in context of maize

Jaunsar tribal area in Uttarakhand comprising Kalsi and Chakrata blocks in Dehradun district is traditionally a maize growing area. Of the total 27,895 thousand hectare area under maize cultivation in Uttarakhand, district Dehradun, with a total area of 9,115 thousand hectare, accounts for about 33% of the

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total maize area in the state. About 45% of this area is located in the hill region of the district, represented mainly by Kalsi and Chakrata tribal blocks[4].

Kwanu tribal cluster

Kwanu tribal cluster in Chakrata block is among the largest maize growing clusters in Jaunsar region ($30^0$40′52″N, $77^0$45′49″E, 780 m amsl). The cluster comprises three major villages (Mailot, Majhgaon and Kota) and is spread over an expanse of over 400 acres (Fig. 1). The cluster is situated on the bank of river Tons that joins river Yamuna downstream at Haripur and demarcates it from adjoining district Sirmour of Himachal Pradesh. As elsewhere in the Jaunsar region, maize is a major constituent of the staple diet in Kwanu cluster and is consumed mainly in the form of *roti* (round unleavened flat bread). Rainy season (*Kharif*) is the main maize growing season and almost 80% area during the season is occupied by maize. Barring occasional fields of hybrid maize (provided by public/private seed agencies/research institutions for demonstrations), the entire area is planted with the traditional local open-pollinated cultivar (hereinafter referred to as ‘Kwanu Local’).

‘Kwanu Local’ maize

‘Kwanu Local’ is a tall, high yielding, medium duration and semi-dent yellow-grain cultivar that has been contributing significantly towards sustaining food, fodder and fuel requirement of the farming community since as far back as the memory of local folk goes (Fig. 2).

Local cultivars/landraces are important reservoirs of agronomic and nutritional traits and are a useful resource for creation of novel gene assemblages and/or discovery of such naturally existing constellations required for sustaining high yields of hybrids necessitates continued efforts for. Traditional local cultivars are an important source of the latter.

Maize productivity in the country has witnessed significant advances in the last couple of decades owing chiefly to wide scale cultivation of high yielding hybrids. Sustaining high yields of hybrids necessitates continued efforts for creation of novel gene assemblages and/or discovery of such naturally existing constellations. While novel gene assemblages are created through systematic hybridization among select genetic stocks, traditional local cultivars and landraces are an important source of such naturally existing assemblages, which can be directly utilized in maize improvement programmes. The local cultivar ‘Kwanu Local’ with its high yield coupled with other desirable agronomic traits showed promise as a potential genetic resource and was, therefore, used in the present study.

Methodology

Collection of Kwanu Local seed

Twenty ears of Kwanu Local maize were randomly collected from the ear-bunches hung outside their homes by the farmers for use as seed in the following season (Fig. 2b). The seed from the ears was removed

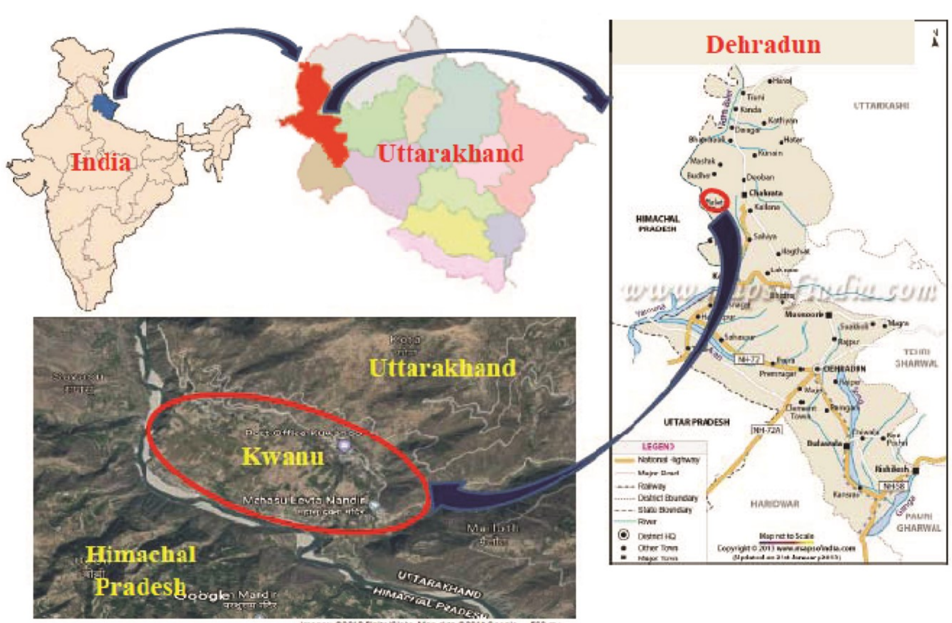

Fig. 1 — Location of Kwanu cluster

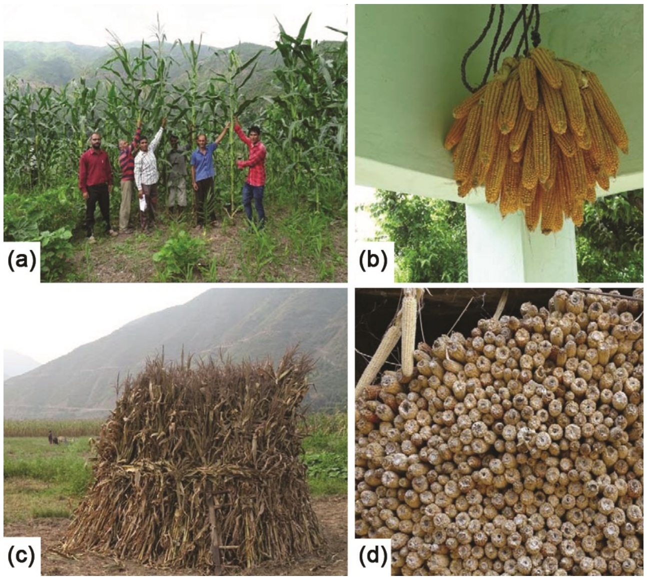

Fig. 2 — (a) Plants of Kwanu Local (b) Selected ears for seed (c) Stover for fodder (d) Cobwood for fuel

manually and mixed together to form a single bulk. A random sample was drawn from the seed bulk for conducting agronomic trials.

Evaluation of yield and other agronomic characters

The performance of Kwanu Local was evaluated with check hybrid VMH 45 in a Station Trial at ICAR-VPKAS, Experimental Farm, Hawalbagh, Almora during *Kharif* 2016. The trial consisted of 22 entries (including 20 experimental hybrids) grown in a Randomized Complete Block Design (RCBD) with two replications. Each entry was planted in 2 rows of 3 m length. Row-to-row and plant-to-plant spacing was maintained at 60 and 25 cm, respectively. The observations on plant height (PH), cob length (CL), cob girth (CG), kernel rows (KR), number of kernels per kernel row (KKR), kernel weight (KW), days to 75% dry husk (75% DH) and yield/ha (YLD) were recorded following the standard methods. In addition, the yield of VL maize hybrids, namely, VMH 25, VQPM 9, VMH 45 and VMH 47 was also compared with Kwanu Local in Front Line Demonstrations conducted in Kwanu cluster during *Kharif* 2016.

Proximate analysis

Moisture%: Moisture content was determined by the oven-dry method[5]. It consists of taking a sample of approximately 5 g, determining its exact weight, and drying the sample in an oven at a temperature of 65 centigrade for 24 h, then weighing the sample and determining the moisture loss by subtracting the oven-dry weight from the moist weight. Moisture content is expressed as a percentage of the oven-dry weight of the sample.

Crude protein %: Total nitrogen amount was determined by Kjeldahl Process[5] based on the theory that a plant contains 16 g of nitrogen in 100 g of total protein. Crude protein content was calculated using the formula, protein = nitrogen×6.25.

Fat %: Soxhlet method was used for determination of total fat content[6].

Total carbohydrate %: Total sugar content (TSS) was determined spectrophotometrically by Anthrone method[7].

Generation of top-crosses and back-cross (BC) populations

Top-crosses of five elite inbreds, namely, VQL 1, V 407, V 390, V 400 and V 467 with Kwanu Local (OPV) were generated during at ICAR-VPKAS, Experimental Farm, Hawalbagh, Almora during *Kharif* 2016 following standard breeding procedures. Backcross population BC_1F_1 was generated during *Rabi* 2016-17 at ICAR-IIMR Winter Nursery Centre, Hyderabad. $BC_2F_1$and BC_2F_2 populations were generated at ICAR-VPKAS, Experimental Farm, Hawalbagh, Almora during *Kharif* 2017 and *Kharif* 2018, respectively. During *Kharif* 2018, 10-15BC_2F_1 progenies of each cross were raised along with Kwanu Local and the five original inbreds. Agronomically superior plants phenotypically closer to the original inbreds were pollinated again with the respective inbred line (second round of backcrossing). During backcrossing, the ears with pollinated with ample pollen to ensure good seed set. The pollinated ears from the selected plants were harvested and shelled separately. The shelled seed was visually observed and BC_2F_1 individuals with seeds apparently bolder than the original inbred lines were identified. Two samples of 100 seeds each of the identified BC_2F_1 individual were weighed using a digital balance for recording kernel weight. Seed samples of the five inbred lines (VQL 1, V 407, V 390, V 400 and V 467) and Kwanu Local were also weighed for comparison with the seed weight of the identified BC_2F_1 individuals.

Results and discussion

The key agronomic characteristics of Kwanu Local and its yield performance vis-à-vis VL maize hybrid and composite varieties are given in Table 1 and Table 2, respectively. The maize hybrids, VMH 45 and VMH 53, used in the study are single-cross hybrids. The male parents of both the hybrids are of

Table 1 — Key agronomic traits of Kwanu Local and VL varieties (*Kharif* 2016; ICAR-VPKAS, Almora)

Variety	PH	CL	CG	KR	KKR	KW	75% DH	YLD
Kwanu Local	285	19.7	16.1	12.0	38.7	346	100	6,083
VSM 37 (composite)	205	16.6	13.1	13.0	34.3	217	90	-
VMH 45 (hybrid)	200	18.9	15.3	14.3	36.9	369	90	6,853
VMH 53 (hybrid)	200	18.3	15.4	15.2	35.4	374	91	-

PH=Plant Height (cm); CL=Cob Length (cm); CG=Cob Girth (cm); KR=Kernel Rows (no.); KKR=Kernels/Kernel Row (no.); KW=Kernel Weight (weight of 100 kernels) (g); 75% DH=Days to 75% Dry Husk; YLD=Yield (Kg/ha.)

Table 2 — Yield of Kwanu Local and VL maize hybrids (*Kharif* 2016; Kwanu cluster)

Hybrid / Variety	Yield (kg/ha)	Superiority over Kwanu Local (%)
VMH 25	5,636	9.0
VQPM 9	5,780	11.8
VMH 45	5,875	13.6
VMH 47	6,239	20.7
Kwanu Local	5,170	-

CIMMYT (Mexico) origin, whereas the female parents have been derived from a private seed sector hybrid. The composite variety VL Sankul Makka 31 has been derived from indigenous heterotic pools Early Yellow Hill Pool I (EHYP I) and Early Yellow Hill Pool II (EHYP II). Compared to the VL varieties, Kwanu Local is taller and late in maturity. It is comparable with the hybrids for cob length and cob girth (Fig. 3). Kernel rows are marginally less in Kwanu Local and kernels/kernel row is relatively higher. However, when compared to the composite variety VSM 37, Kwanu Local is superior for most of the yield contributing traits (CL, CG, KR, SW). Particularly, the grain of Kwanu Local is much bolder (SW 59.4% higher than VSM 37).

The average yield of Kwanu Local (5,170 kg/ha) was quite remarkable by standards of local cultivars and scientifically bred composite varieties. The yield difference between Kwanu Local and popular VL maize hybrids (9-20.7%) fell in a relatively narrow range, whereas common local hill cultivars fall behind the hybrids by as much as over 50%. The crude protein content of Kwanu Local was higher, whereas the fat and total carbohydrate content was lower compared to popular VL varieties and composites (Table 3.)

As elsewhere in the rural agrarian communities[8], the practice of crop and varietal seed exchange accompanying marriages has been a characteristic of Jaunsar region as well. Since tribal region extends into adjoining Himachal Pradesh, inflow of maize seed from different parts of Himachal Pradesh through commodity exchanges and family associations has been a common feature. Exchanging seed stocks with or using stocks of farmers within or outside the community is also frequently practiced. Moreover, by virtue of relatively easy accessibility, elite materials in the form of public OPVs and public and private sector hybrids have been in regular flow into Kwanu cluster. The Kwanu Local population in its present form is a product of inter-breeding among various types that existed in this area at one point in time or the other, each blending uniquely in the base population and contributing to its characteristic form and the process is ongoing.

Table 3 — Proximate analysis of Kwanu Local and VL maize varieties

Hybrid / Variety	Moisture %	Crude protein %	Fat %	Total carbohydrate %
VMH 45 (hybrid)	9.45	9.17	1.71	65.42
Kwanu Local	10.15	10.13	0.95	57.63
VSM 35 (composite)	9.31	9.10	1.43	68.21
VSM 31 (composite)	9.15	8.92	1.73	66.39

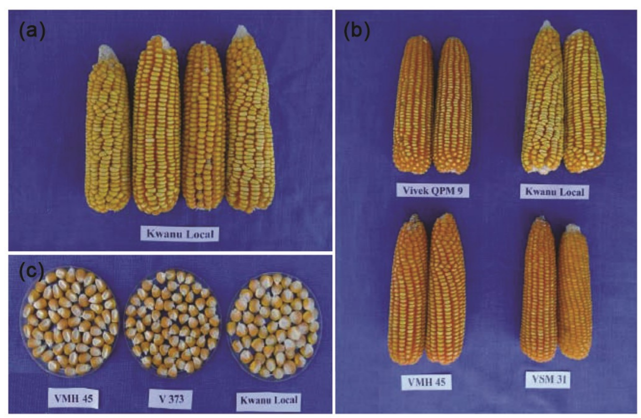

Fig. 3 — (a) Ears of Kwanu Local (b) Ears and seed of Kwanu Local and VL maize varieties (c) Seeds of Kwanu Local, hybrid VMH 45 and inbred V 373

Seed maintenance practices

Farmer-produced seed is the most important source of planting material in the world. Depending on the crop and country, 60-100% of the seed planted in developing countries is farmer produced and exchanged[9]. In maize, farmers use several variations of mass selection in the maintenance and selection of their varieties. Most commonly, they use positive mass selection, thus selecting better performing plants for seed production[10]. In Kwanu area, at the time of dehusking the harvested ears, farmers select superior ears with fairly uniform grain characteristics. The selected ears are bunched together and hung up outside homes for drying. Adequately dried ears are shelled, manually graded and healthy bold grains preserved for use as seed. Simultaneous cultivation over a vast contiguous expanse allows large-scale inter-mating among the constituent individuals leading to maintenance of high heterozygosity in the population, assuring sustained high yields. Regular infusion of novel gene constellations into the population is brought about by periodic cultivation of new hybrids from public and private seed sector. The ensuing cycles of selection for yield, maturity and plant height ensure that the basic phenotype remains largely unchanged while assimilating yield enhancing genes from the donor populations. Louette and Smale[11], in a study conducted in Cuzalapa community in Mexico, also reported the role of exertion of such seed selection pressures by farmers in favouring more productive genotypes for the region's growing conditions and protecting the phenological integrity of the traditional maize varieties even though other characteristics may continue to evolve.

A potential genetic resource

Inbred lines derived from local populations constitute a reservoir of genetic diversity[12] and besides possessing variability for important agronomic traits, may exhibit different heterotic pattern and potential than those derived from exotic populations[13]. In order for a newly developed variety to succeed in the targeted niche, it must have the ability to adapt to the agro-ecology the niche characterizes, and the preferred strategy to ensure that is to have a sizeable proportion of locally adapted genotype (s) in its background. On account of its local adaptability and agronomic superiority,

Kwanu Local very suitably fits this requirement for developing new maize varieties for the hills of Uttarakhand and other similar agro-ecologies in the country.

Further, its higher kernel weight (which coupled with higher grain number is a much sought-after trait

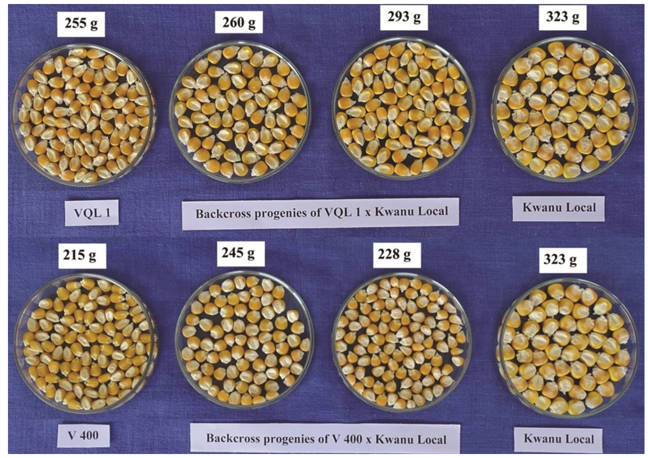

Fig. 4 — Increased kernel size in backcross progenies of inbreds VQL 1 and V 400 with Kwanu Local

combination in HYVs) renders it a genotype of choice for use as a donor for this trait as well. Breeding material generated at ICAR-VPKAS, Almora using Kwanu Local has demonstrated its successful use for enhancing kernel size (Fig. 4). Two inbreds (VQL 1 and V 400) that possess many desired traits but have lower kernel weight (VQL 1 – 25.5 g and V 400 – 21.5 g) were used as recipients with Kwanu Local as the donor for high kernel weight (32.3 g). The backcross generations (BC_2F_1) of the two crosses yield progenies with high kernel weight ranging from 26.0-29.3 g (VQL x Kwanu Local) and 22.8-24.5 g (V 400 x Kwanu Local). Kernel weight increase in the two crosses ranged from 6-14 and 2-15%, respectively. These progenies with higher kernel weight would serve as potential sources for developing high yielding hybrids with bolder grains.

Conclusion

Maize productivity has increased significantly in the last few decades due to wide scale cultivation of high yielding hybrids. Traditional local cultivars, with their broad genetic base and diversity, are important source populations for creating potential stocks for use in hybrid development programmes. With its local adaptability and high yield coupled with other agronomically desirable traits, Kwanu Local is a promising genetic resource for maize improvement programmes in the country. The cultivar is also a potential candidate for registration as a Farmer Variety with PPV & FR Authority and efforts in this direction have been initiated by ICAR-VPKAS, Almora. Registration of the cultivar as a farmer variety will be a well-deserved recognition of the contribution of the tribal farming community in maintaining this potential genetic resource over the past several years.

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