VOL. 3, NO. 3, MAY 2008 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

EVALUATION OF YIELD OF COMPONENTS OF SORGHUM/COWPEA INTERCROPS IN THE SUDAN SAVANNA ECOLOGICAL ZONE

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ABSTRACT
An experiment to evaluate the performance of some improved cowpea genotypes intercropped with sorghum in single alternate row arrangement was conducted at Minjibir, Kano, Nigeria. 30 cowpea genotypes differing in maturity and growth habits and local sorghum variety were used. The results indicated that a medium maturing genotype, IT95K-222-14 produced the highest grain yield while Danila, a medium maturing improve local cultivar, recorded the highest fodder yield. Some late maturing, spreading cowpea genotypes produced little or no grain yield. The yield and yield components of sorghum were not affected by cowpea genotype. Analysis of the intercrop productivity (LER) demonstrated that intercropping sorghum with IT95K-222-14 gave the highest value (1.88). Based on high grain and fodder yields, intercrop productivity Danila, IT90K-277-2, IT95K-1091-3, IT96D-759, IT96D-666 and IT95K-222-14 could be selected for improving the productivity of sorghum/cowpea mixture in the Sudan savanna.

Keywords: sorghum, cowpea, genotypes, intercropping, production, Nigeria.

INTRODUCTION
Intercropping is the growing of two or more crops together on the same piece of land at the same time in a haphazard or systematic manner that the growth of some or all the component plant types overlap in space and time (Elemo *et al.*, 1990). In a survey conducted in the former Zaria Province of Nigeria, Norman (1974) found that about 82% of the land grown to crops was under intercropping system. Similarly, Elemo *et al.*, (1990) observed intercropping as a common practice among traditional farmers of the Nigerian savanna. They indicated that not less than 60 - 70% of the cropped land is devoted to growing of crops in mixtures. A more recent survey by Henriet *et al.*, (1997) and van Ek *et al.*, (1997) showed that mixed cropping was the predominant system in the Sudan savanna of Nigeria, with millet/cowpea, sorghum/cowpea, sorghum/groundnut and millet/groundnut intercrops being the most important. Under the traditional practice in northern Nigeria, sorghum, millet, groundnut, cotton, and cowpea are predominantly grown in mixtures (Norman, 1972). Baker (1978) observed that in the tropics, cereals are commonly intercropped with legumes, in the hope that the former will benefit from the N-fixed by the later. Other benefits include maximum resource utilization and income stability (Abalu, 1976) and higher total returns (Elemo *et al.*, 1990).

Sorghum constitutes the staple food for the bulk of the Nigerian population in the Sudan and Guinea savanna ecological zones (Andrews, 1972). Cowpea is an important food crop throughout West Africa and especially in the Sudan savanna (Singh and Ntare, 1985). In Nigeria, cowpea grains form an important source of cheap vegetable, containing approximately 25% protein (Oyenuga, 1959). Cowpea is predominantly intercropped with millet or sorghum and farmers seldom use plant protection measures under this system. Local varieties show considerable variation but are generally spreading and indeterminate.

They are photoperiod-sensitive and often mature after the end of the rainy season (Anonymous, 1988). Cowpea production in the Sudan-sahelian zone is often limited by inadequate and erratic rainfall. Previous reports by Singh (1997 and 1998) indicated that there are opportunities for improving the productivity of sorghum/cowpea intercrop using newly developed cowpea varieties. The objective of the present study is to screen some improved cowpea lines for intercropping with sorghum in the Sudan savanna ecological zone

MATERIALS AND METHODS
This study was conducted in 1998 at the Institute of Agricultural Research/International Institute of Tropical Agriculture Research Farm, Minjibir located in the Sudan savanna ecological zone of Nigeria (lat. 12^0 08'N, long. 8^0 32'E, 500m above sea level). The rainfall pattern is mono-modal with an average annual amount (1961-1990) of 690mm (Craufurd and Wheeler, 1999). Rainfall and weather data during the growing season are presented in Table-1. The treatments consisted of 27 improved and 3 local genotypes of cowpea. Using Randomized Complete Block Design (RCBD), the 30 genotypes were planted in single alternate rows of sorghum and replicated three times.

The land was ploughed, harrowed and ridged (0.75m apart) after the rains have established. The plot sizes consisted of 4 ridges, 75cm apart, 5m long ($15m^2$) for gross area and two 2 ridges 5m long for the net area. Sorghum was sown on 20th June 1998 at the spacing of 75cm x 50cm while the cowpea was planted on 27th June 1998 at the spacing of 75cm x 20cm. At first weeding both sorghum and cowpea were each thinned to 2 plants/stand to obtain the sole plots plant populations of 53,333 and

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133,333, respectively. Sole plots of both crops were established for the determination of Land Equivalent Ratio (LER). The intercrop plant population was a replacement series made up of 50:50 proportions of the sole cereal and cowpea populations in each intercrop combination.

Table-1. Mean monthly weather data for Minjibir in 1998 cropping seasons.

Month	**Rainfall** (mm)	**Temperature** °C		**Relative humidity** %		**Solar radiation** MJ M^{-2}	**Wind speed** km/ha
		Max	**Min**	**Max**	**Min**		
April	4.3	39.6	25.0	42	10	24.3	3.7
May	42.4	36.5	24.7	75	31	22.0	6.5
June	163.3	35.5	24.9	78	41	23.8	6.7
July	242.6	31.2	22.1	86	58	20.9	5.9
August	256.3	30.0	21.9	91	62	18.7	4.2
September	189.4	33.0	22.5	82	45	21.4	3.2
October	22.8	35.6	19.5	59	23	22.0	3.0
November	0.0	34.2	14.2	41	10	22.0	3.2
Total/ Average	921.1	34.4	21.9	69.3	35.0	21.9	4.6

Each plot received a basal application of 30 kg N, 13 kg P and 24.3 kg K/ha as urea, single superphosphate and muriate of potash, respectively at land preparation. The sorghum plants were top-dressed at 5 weeks after planting with 30 kgN/ha in form of urea.

Cowpea plants were not sprayed against insect pests. Weeding was accomplished using hand hoes at 3 and 6 weeks after cereal planting. After harvesting the net plots the following data were recorded for the cowpea component; pod length, number of pods/plant, number of grains/pod, 100-grain weight, grain yield and partial LER of cowpea. Sorghum data were recorded in respect of panicle length, number of panicles/m^2, 1000-seed weight and threshing percentage. Intercrop productivity was evaluated using Land Equivalent Ratio (LER) as described by Willey (1979). The data was analyzed using SAS (SAS, 1988) following the procedure described by Snedecor and Cochran (1967) and means of treatments were separated using DMRT (Duncan, 1955).

RESULTS

Cowpea yield components

Cowpea genotype had significant effect on pod length of cowpea intercropped with sorghum (Table-2). The cowpea genotypes IT95K-222-14 and IT96D-738 had significantly longer pods than the improved local Danila and IT96D-740 while the other genotypes had similar and intermediate pod lengths. The results indicated that IT95K-1091-3 and IT94K-2052-3 had significantly higher number of pods/plant than IT93K-734, Danila and IT96D-740 which were at par while the other genotypes had intermediate number of pods/plant (Table-2). With the exception of IT95K-1133-2 and Kanannado, all the genotypes had similar number of grains/pod (Table-2). One hundred-grain weight of cowpea genotypes intercropped with sorghum differed significantly (Table-2). IT95K-1091-3, IT96D-666, IT90K-277-2, IT96D-759, IT95K-222-14, IT89KD-288, IT94K-410-2, IT96D-651 and IT94K-2052-3 had significantly heavier grains than IT96D-740 and Danila while all other genotypes had intermediate grain weights.

Sorghum yield components

Cowpea genotype had significant effect on panicle length, panicle weight/m^2 and threshing percentage of sorghum (Table-3). However, 1000-seed weight of sorghum was significantly affected by cowpea genotype with IT95K-222-14 having statistically superior values to compared IT95K-1091-3, while the other genotypes had similar and intermediate values.

VOL. 3, NO. 3, MAY 2008 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

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Table-2. Pod length, number of pods/plant, number of grains/pod, 100-grain weight and threshing percentage of cowpea intercropped with sorghum at Minjibir, 1998.

Cowpea genotype	**Pod length** (cm)*	**Number of pods/plant***	**Number of grains/pod***	**100-grain weight** (g)*
Early maturing				
IT95K-719-3	16.3_{abc}	14.0_{ab}	13.3_{a}	17.5_{abc}
IT93K-437-1	16.3_{abc}	15.0_{ab}	14.3_{a}	18.8_{ab}
IT94K-410-1	15.0_{abc}	18.3_{ab}	13.0_{a}	19.4_{ab}
IT96D-612	17.3_{abc}	15.7_{ab}	12.0_{a}	18.9_{ab}
IT93K-596-9-12	15.7_{abc}	13.7_{ab}	15.0_{a}	17.4_{abc}
IT94K-440-3	16.3_{abc}	17.7_{ab}	11.7_{a}	19.4_{ab}
IT94K-410-2	15.3_{abc}	18.7_{ab}	13.3_{a}	20.1_{a}
IT93K-513-2	16.3_{abc}	11.3_{ab}	12.7_{a}	19.9_{ab}
Medium maturing				
IT95K-1091-3	16.0_{abc}	20.3_{a}	13.0_{a}	20.1_{a}
IT96D-666	16.7_{abc}	14.0_{ab}	12.0_{a}	20.3_{a}
IT90K-277-2	16.3_{abc}	16.3_{ab}	13.3_{a}	20.3_{a}
IT96D-772	16.7_{abc}	13.7_{ab}	14.0_{a}	19.9_{ab}
IT93K-734	14.7_{abc}	10.0_{bc}	12.7_{a}	18.8_{ab}
IT96D-759	14.3_{abc}	17.0_{ab}	10.3_{a}	21.0_{a}
IT95K-222-14	18.0_{a}	13.0_{ab}	13.3_{a}	21.0_{a}
IT96D-738	17.7_{a}	15.3_{ab}	14.0_{a}	19.7_{ab}
IT96D-757	13.7_{abc}	12.0_{ab}	11.0_{a}	19.4_{ab}
IT96D-740	12.0_{bc}	10.3_{bc}	10.7_{a}	13.0_{c}
DANILA	11.3_{c}	10.7_{bc}	9.3_{a}	13.9_{bc}
IT96D-684	14.3_{abc}	15.7_{ab}	12.7_{a}	18.6_{abc}
IT95K-52-34	16.0_{abc}	13.3_{ab}	11.7_{a}	19.6_{ab}
IT96D-602	14.7_{abc}	14.0_{ab}	11.0_{a}	19.0_{ab}
IT94K-2058-14	15.3_{abc}	13.0_{ab}	11.7_{a}	19.7_{ab}
IT96D-651	17.3_{ab}	13.7_{ab}	13.0_{a}	20.6_{a}
IT89KD-349	14.7_{abc}	17.3_{ab}	13.3_{a}	19.4_{ab}
Late maturing				
ALOKA	14.7_{abc}	12.7_{ab}	13.0_{a}	17.9_{abc}
Kanannado	3.0_{d}	3.0_{c}	3.0_{b}	3.0_{d}
IT95K-1133-2	3.0_{d}	3.0_{c}	3.0_{b}	3.0_{d}
IT89KD-288	16.0_{abc}	15.0_{ab}	11.7_{a}	20.5_{a}
IT94K-2052-3	15.0_{abc}	20.3_{a}	11.3_{a}	20.1_{a}
SE ±	1.54	2.67	1.62	1.75

Means followed by the same letter (s) within treatment are not significantly different at 5% using Duncan Multiple Range Test. * Data was transformed by adding +3 to all the values.

Table-3. Panicle length, number of panicles/m^2, 1000-seed weight and threshing percentage of sorghum intercropped with cowpea.

Cowpea genotype	Panicle length (cm)	Number of panicles/m^2	1000 seed weight (g)	Threshing (%)
Early maturing				
IT95K-719-3	29.73	6.60	38.95_{ab}	67.33
IT93K-437-1	31.77	5.47	38.15_{ab}	69.67
IT94K-410-1	31.03	5.27	37.82_{ab}	65.33
IT96D-612	31.40	5.13	39.40_{ab}	60.00
IT93K-596-9-12	31.70	5.53	38.42_{ab}	65.33
IT94K-440-3	31.53	6.47	38.47_{ab}	61.67
IT94K-410-2	30.20	6.00	38.70_{ab}	67.33
IT93K-513-2	30.57	5.60	37.82_{ab}	55.00
Medium maturing				
IT95K-1091-3	31.20	5.67	37.13_{ab}	61.67
IT96D-666	27.87	6.13	38.60_{ab}	65.00
IT90K-277-2	30.40	5.47	39.13_{ab}	67.00
IT96D-772	29.83	5.53	39.22_{ab}	53.33
IT93K-734	33.17	5.27	38.88_{ab}	56.00
IT96D-759	33.40	6.13	38.37_{ab}	55.33
IT95K-222-14	33.37	5.93	39.80_{ab}	71.00
IT96D-738	30.10	6.33	38.03_{ab}	73.00
IT96D-757	30.40	6.73	38.70_{ab}	62.00
IT96D-740	31.17	5.40	38.78_{ab}	60.67
DANILA	31.80	5.27	38.15_{ab}	67.00
IT96D-684	30.93	5.40	38.83_{ab}	59.67
IT95K-52-34	31.87	6.00	39.32_{ab}	65.00
IT96D-602	31.30	5.07	38.70_{ab}	57.00
IT94K-2058-14	31.37	3.60	38.67_{ab}	43.33
IT96D-651	31.70	4.07	38.17_{ab}	59.00
IT89KD-349	32.70	4.07	39.02_{b}	41.00
Late maturing				
ALOKA	30.97	4.27	39.10_{ab}	63.67
Kanannado	31.07	4.53	39.30_{ab}	58.00
IT95K-1133-2	30.53	6.60	38.48_{ab}	69.33
IT89KD-288	30.93	5.53	38.83_{ab}	80.00
IT94K-2052-3	30.80	5.20	38.47_{ab}	47.00
SE $\pm$	1.29	0.79	0.73	8.01

Means followed by the same letter (s) within treatment are not significantly different at 5% using Duncan Multiple Range Test.

Yields of cowpea and sorghum

The results show that cowpea genotypes had significant effect on grain yield of cowpea intercropped with sorghum. The cowpea genotype IT95K-222-14 had a significantly higher grain yields than the other genotypes (Table-4), though the differences between IT90K-277-2, IT96D-612 and IT95K-222-14 were not significant. Sole grain yield of cowpea genotypes ranged from 0 to 546.7 kg/ha.

Fodder yield of cowpea was significantly affected by cowpea genotype (Table-4). Medium maturing Danila and IT89KD-349 had significantly higher fodder yields compared with the other genotypes while the differences of fodder yields of IT96D-666, IT90K-277-2, IT93K-734, IT96D-757, IT96D-738, IT89KD-288, Danila and IT89KD-349 were not significant. Both grain and stover yields of sorghum were not affected by cowpea genotype (Table-4).

Intercrop productivity (LER)

The results indicated that IT95K-222-14 had a significantly higher partial land equivalent ratio than the other genotypes though the differences between IT90K-277-2, IT96D-612 and IT95K-222-14 (Table-5) was statistically not significant. However, the partial LER of sorghum was not affected by cowpea genotype (Table-5). When the total LER was considered, the results revealed that sorghum intercropped with IT95K-222-14 had significantly higher total LER than the other genotypes, which were similar except IT95K-719-3, IT90K-277-2 and IT94K-410-2, which were statistically similar compared to IT95K-222-14 (Table-5).

Table-4. Grain and fodder yields of cowpea, grain yield of sorghum in sorghum/cowpea intercrop (and their sole grain yields) under no spray condition at Minjibir, 1998.

Treatment	**Sole cowpea***	**Intercrop yield** (kg/ha)			
		Sorghum		**Cowpea**	
Cowpea genotype		**Grain**	**Fodder**	**Grain***	**Fodder**
Early maturing					
IT95K-719-3	347	1354	6300	306$_{c-f}$	475$_{f-j}$
IT93K-437-1	293	1212	4967	284$_{c-f}$	542$_{e-j}$
IT94K-410-1	320	1035	5367	273$_{c-g}$	475$_{f-j}$
IT96D-612	437	876	5233	370$_{abc}$	400$_{g-j}$
IT93K-596-9-12	441	1125	5500	226$_{c-h}$	392$_{hij}$
IT94K-440-3	321	1184	7800	215$_{c-i}$	875$_{b-i}$
IT94K-410-2	398	1314	7067	337$_{bcd}$	617$_{d-j}$
IT93K-513-2	306	808	4467	289$_{c-f}$	292$_{j}$
Medium maturing					
IT95K-1091-3	401	947	4933	278$_{c-f}$	1075$_{b-e}$
IT96D-666	396	1406	7033	272$_{c-g}$	1192$_{abc}$
IT90K-277-2	403	1303	6467	513$_{ab}$	1317$_{ab}$
IT96D-772	400	711	3817	194$_{c-i}$	892$_{b-h}$
IT93K-734	470	1075	5333	71.9$_{ghi}$	1333$_{ab}$
IT96D-759	318	729	5000	292$_{c-f}$	933$_{b-h}$
IT95K-222-14	466	1465	5183	525$_{a}$	917$_{b-h}$
IT96D-738	437	1683	7600	159$_{d-i}$	1333$_{ab}$
IT96D-757	268	1227	5917	169$_{c-i}$	1272$_{ab}$
IT96D-740	306	962	5500	205$_{c-i}$	958$_{bcg}$
DANILA	377	1293	5767	219$_{c-i}$	1667$_{a}$
IT96D-684	397	986	4817	322$_{c-f}$	583$_{e-j}$
IT95K-52-34	199	1183	6500	286$_{c-f}$	1092$_{b-e}$
IT96D-602	442	764	4200	333$_{b-e}$	1100$_{b-e}$
IT94K-2058-14	298	489	2900	128e-i	1042$_{b-e}$
IT96D-651	308	962	4667	220c-i	325$_{ij}$
IT89KD-349	271	649	3467	173c-i	1675$_{a}$
Late maturing					
ALOKA	181	928	4150	115$_{f-i}$	383$_{hij}$
Kanannado	20	1076	6167	20$_{i}$	975$_{b-f}$
IT95K-1133-2	20	1422	5833	20$_{i}$	783$_{b-j}$
IT89KD-288	236	1079	5400	46$_{hi}$	1167$_{a-d}$
IT94K-2052-3	356	658	4867	269$_{c-g}$	667$_{c-j}$
SE $\pm$	4.2	348.2	1255	60.0	166.1
Sole sorghum yield	1385				

Means followed by the same letter (s) within treatment are not significantly different at 5% using Duncan Multiple Range Test. * Data was transformed by adding +20 to all values.

Table-5. Land equivalent ratio of cowpea genotypes, their sorghum components and total LER at Minjibir, 1998.

Cowpea genotype	Partial LER		Total LER*
	Cowpea*	Sorghum	
Early maturing			
IT95K-719-3	0.69_{c-f}	0.65	1.34_{a-d}
IT93K-437-1	0.64_{c-f}	0.57	1.21_{a-e}
IT94K-410-1	0.61_{c-g}	0.50	1.11_{b-e}
IT96D-612	0.83_{abc}	0.42	1.25_{a-e}
IT93K-596-9-12	0.51_{c-h}	0.52	1.03_{b-e}
IT94K-440-3	0.48c-i	0.57	1.05_{b-e}
IT94K-410-2	0.76_{bcd}	0.62	1.38_{abc}
IT93K-513-2	0.65_{c-f}	0.39	1.04_{b-e}
Medium maturing			
IT95K-1091-3	0.62_{c-g}	0.45	1.07_{b-e}
IT96D-666	0.61_{c-g}	0.67	1.28_{a-e}
IT90K-277-2	1.15_{ab}	0.62	1.77_{ab}
IT96D-772	0.44_{c-i}	0.34	0.78_{ab}
IT93K-734	0.17_{ghi}	0.51	0.68_{cde}
IT96D-759	0.66_{c-f}	0.34	1.00_{b-e}
IT95K-222-14	1.17_{a}	0.71	1.88_{a}
IT96D-738	0.36_{d-i}	0.80	1.16_{a-e}
IT96D-757	0.38_{c-i}	0.59	0.97_{cde}
IT96D-740	0.46_{c-i}	0.46	0.92_{cde}
DANILA	0.49_{c-i}	0.62	1.11_{b-e}
IT96D-684	0.72_{c-f}	0.47	1.19_{a-e}
IT95K-52-34	0.64_{c-f}	0.57	1.21_{a-e}
IT96D-602	0.75_{bcd}	0.36	1.11_{b-e}
IT94K-2058-14	0.29_{e-i}	0.23	0.52_{e}
IT96D-651	0.49_{c-i}	0.47	0.96_{cde}
IT89KD-349	0.39_{c-i}	0.26	0.65_{cde}
Late maturing			
ALOKA	0.26_{f-i}	0.45	0.71_{cde}
Kanannado	0.05_{i}	0.52	0.57_{de}
IT95K-1133-2	0.05_{i}	0.68	0.73_{cde}
IT89KD-288	0.11_{hi}	0.51	0.62_{cde}
IT94K-2052-3	0.60c-$_{h}$	0.31	0.91_{cde}
SE $\pm$	0.3	0.17	0.22

Means followed by the same letter (s) within treatment are not significantly different at 5% using Duncan Multiple Range Test. * Data was transformed by adding +0.05 to all values.

DISCUSSIONS

The results demonstrated that a medium maturing genotype IT95K-222-14 produced the highest grain yield under intercropping with sorghum. Although this superiority was supported by higher yield components, the genotype could have superior adaptability for intercropping and tolerant to major insect pests (Singh, 1998). Expectedly, all the yield components of the intercropped cowpea; pod length, number of grains per pod, number of pods per plant and 100-seed weight, showed significant variations with cowpea genotype. Such differences could have stemmed from the varied nature or growth habits of the genotypes. According to Anonymous (1985) yield and yield components of cowpea are genetically controlled although subject to environmental influences. Under the traditional practice farmers hardly use insecticides to protect insects of cowpea. Thus, in the present study the cowpea plants were not protected against insect pest and this was to enable selection of genotypes with high tolerance to the major insect pests. There were significant variations in fodder yields among the intercropped cowpea genotypes with the highest fodder yield being produced by Danila, which is an improved local medium maturing genotype. Previous studies by Singh (1997) had indicated that Danila produces high fodder and satisfactory grain yield under intercropping situations. Among the late maturing genotypes, Kanannado and IT95K-1133-2, which are spreading, indeterminate, late maturing cultivars did not produce any grain. Although late maturing cultivars have low harvest index (Terao *et al.,* 1997; Ntare, 1990), the zero grain yield recorded by the two genotypes could be due to heavy insect pest damage since insect control measures were not applied.

The results indicated that panicle length, panicle weight/m^2 and threshing percentage of sorghum were not affected by cowpea genotype while sorghum under mixture with IT95K-222-14 recorded significantly heavier grains (100-seed) compared with the other genotypes. This is an indication that the local sorghum did not suffer severe competition from the companion IT95K-222-14. Conversely, the superior 1000-seed weight recorded by local sorghum could be attributed to moderate competition from the companion IT95K-222-14. The non-significant effect of cowpea genotype on sorghum grain and stover yields recorded in this study conforms to results obtained by Reddy *et al.,* (1992). Several workers have indicated that the effect of cowpea on the companion sorghum grain yield is little (Ntare et al. 1989; Isenmilla *et al.,* 1981). In cereal/legume intercrops, the cereals are mostly unaffected most probably in view of their tall canopy structure which enables them to capture sufficient light.

The results of the intercrop productivity measured using LER indicated that intercropping sorghum with IT95K-222-14 recorded the highest total LER. This is not surprising since IT95K-222-14 recorded the highest grain yield both under intercropping and sole cropping. The partial LER of cowpea was affected by cowpea genotype with IT95K-222-14 having significantly higher values compared to other genotypes. However, the partial LER of sorghum did not differ significantly among the cowpea genotypes. This further attests to the fact that the intercropped sorghum was little affected by the cowpea as reported by Odion (1990).

From the above it can be concluded that there are opportunities for improving the productivity of sorghum/cowpea in the Sudan savanna ecological zone using the varieties developed by the International Institute of Tropical Agriculture (IITA). Medium maturing genotypes appear to out performed the late and early maturing genotypes with respect to grain and fodder yield as well as intercrop advantage. Accordingly, the following genotypes could be selected for adoption; Danila, IT90K-277-2, IT95K-1091-3, IT95K-222-14, I T96D-666 and IT96D-759.

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