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Effect of Gynotype, Age and Season on Reproductive Traits And External Egg Quality of Marshall and Arbor Acre Breeding Stocks

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Abstract

The study was conducted at the Poultry Production Unit (PPU), Ministry of Agriculture and Animal Husbandry, Gombe, Gombe State, Nigeria to determine the effect of genotype age and season on fertility, hatchability, embryonic mortality and external egg quality on Marshall and Arbor acre broiler breeding stocks. A total of 2000 birds comprising 1000 each of Marshal and Arbor acre were used to obtain the data according to genotype, age and season. They were fed commercial diets and water was provided ad-libitum. Fertility, hatchability, early embryonic mortality (EEM) and late embryonic mortality (LEM) was calculated and presented in percentage. Egg external egg qualities were measured in g (weight), cm (length and width) and % (egg shape index), respectively. The data were subjected to analysis of variance (ANOVA) using General Linear Model while Duncan's Multiple Range was used to separate their means. The overall means for fertility, hatchability, EEM, and LEM were 88.09, 82.60, 7.84 and 9.81 %, respectively. Effect of genotype was significant (P < 0.05) on EEM and LEM but fertility and hatchability were not significant. Age and season were significant (P < 0.05) on all traits. The effect of genotype on egg weight (EW), egg length (EL), egg width (EWD) and egg shape index (ESI), were non-significant (P > 0.05), respectively. There was significant (P < 0.05) effect of age on egg weight, egg length, egg width and egg shape index. Egg weight was affected most by age 1 (26-34 weeks), followed by age 2 (35-43 weeks), while the least affected at age 3 (44-45 weeks) of age. ***There was significant (P < 0.05) effect of season on egg weight, egg length and weight but not on egg shape index.*** *The study concluded that age and season had significant effects on fertility, hatchability and mortality as well as other traits, hence, there is need to adjust for these factors towards attaining optimal performance of these reproductive traits meanwhile, the best time for rearing broiler breeding stock in the study area is the dry cold season. Improving profit maximization, poultry breeders and farmers should give adequate management and required nutrition during the earlier stage of growth and also during dry hot and rainy season in order to improve the reproductive performance and avoid mortality in these broiler breeder stocks of chicken especially Arbor acre.*

Keywords: Reproductive traits, Egg quality, Marshall, Arbor acre and Breeding stocks.

Description of problem

Poultry farmers raised them because they provide food, eggs, meat and feathers and others raise them as backyard pets and for fresh eggs. The challenge of malnutrition in developing country like Nigeria can be overcome when the human populace has access to affordable balance diet (1). The United Nation/Food and Agricultural Organization estimated the minimum protein requirements of 70 g/head/day out of which 34 g should be derived from animal protein sources (2). Nigeria consumes about 25% which is less than the recommended 34 g/head/day animal protein (3). In order to meet up with the demand for daily animal protein intake especially among developing countries there is need for introduction of improved strains of livestock especially chickens. In the tropics, season has been reported to affect animal performance and production (4). External and internal egg qualities have been reported to be among the major important traits for worldwide industry (5). These quality traits of eggs are significant in poultry breeding for their influence on the yield features of the future generation, breeding performance and quality chicks (6).

Fertility and hatchability are major determinants of profitability in hatchery enterprise. High fertility and hatchability of egg in broiler breeders' stock and survivability of the chick are necessary to produce good quality and large number of birds (7). (8) stated that fertility and hatchability are susceptible to genetics and environment factors arising from various sources. Fertility and hatchability are also vital parameters affecting production and profitability in the poultry enterprise (7). (9) reported that many factors contributed to the failure and mortality of fertile eggs to hatch which include insufficient nutrients, storage duration, age, harsh weather condition, season and deficiency of vitamins as well as minerals. The main target of hatcheries is to maximize hatchability with lot of high chick quality, saleable chicks that are demanded by consumers for high performance and viability (10). Mortality plays a major role in determining profit in broiler breeders as it is a function of dead chicks over viable and healthy chicks. Thus, the main target of any broiler hatchery enterprise is to produce fertile eggs with high hatchability and subsequently produce chicks of high quality that are demanded by farmers for their viability and good performance. Therefore, the aim of this study was to determine the effect of genotype, age and season on reproductive traits and external egg quality factors in broilers breeding stocks which will be useful in taking the right management decision in order to optimize production and profit.

Materials and Methods

The experiment was carried out year at the Poultry Production Unit (PPU), Ministry of Agriculture and Animal Husbandry, Gombe, Gombe State, Nigeria. The State is located on latitude 10^0 171 N and longitude 11^0 09' E. The state is located in the Guinea Savannah zone with raining season lasting for about five months and dry season for about seven months. The climatic condition is warm, exceeding 40 ^{0}C during the hottest months (March-May), while the average daily temperature of 34-40 ^{0}C was observed in

April and 27 ^{0}C in August. The relative humidity ranged between 10 to 80 % from January to December and the annual rainfall ranged from 850 mm-1200 mm. The state has 3 seasons namely: Rainy season, ranging from May-September (5 months), dry cold season from October to January (4 months) and dry hot season from February to April (3 months) (11). The birds for the study were purchased at CHI Ibadan, Oyo State, and were vaccinated according to the schedule of North- East, Nigeria. A total of 2000 birds (1000 Marshall and 1000 Abor Acre) with a mating ratio of 10:1 (Females to Male) was used for the study. Birds were housed in 100 per pen separately based on genotype and were fed chick mash containing crude protein level of 19- 20% and ME of 2650 Kcal/kg from 0-8 weeks, grower mash from 8-18 weeks with crude protein level of 14-16% and ME of 2500 Kcal/kg and breeder mash from 18 weeks upward with crude protein level of 17% and 2700 kcal/kg ME, together with fresh water *at libitum*. Birds were kept in well-ventilated deep liter system.

Data collection was on fertility, hatchability, egg weight, egg length, egg width, egg shape index, early embryonic mortality (EEM) and late embryonic mortality (LEM). Percent fertility was calculated as total number of fertile eggs divide by total number of eggs set in a week, multiplied by 100; hatchability was obtained as the total number of eggs hatched in relation to total number of fertile eggs set in the incubator by 100 and percentage early and late embryonic mortality (EEM and LEM) were calculated as number of fertile eggs which stop developing within day 1-10 days and those that occurred within the last 10 days of incubation.

The data was subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) of SAS (12) computer package. Duncan's Multiple Range was used to separate means.

$Y_{ijk} = \mu + A_i + B_j + C_k + e_{ijk}$

Where:

Y_{ijk} = Observation of i th within genotype, jth age and kth season of bird μ = Overall Population mean, A_i = effect of genotype (Mashall and Arbor acre), B_j = effect of age 1 (26 – 34), 2 (35 – 43) and 3 (44 – 45) C_k = effect of season 1 (Dry cold), 2 (Dry hot) and 3 (Rainy) as well as e_{ijk} = Random error.

Results and Discussions

Table 1 shows the effect of genotype, age and season on fertility, hatchability and embryonic mortalities (EEM and LEM). Genotype had significant ($P < 0.05$) effect on embryonic mortalities while fertility and hatchability were not significantly ($P > 0.05$) affected by genotype. This suggests that both genotypes had performed well under the environment where the study was carried out. The finding is in agreement with the report (13) who reported no significant ($P > 0.05$) difference in hatchability between Lyallpur Silver black and Rhode Island Red exotic layer chickens. Fertility obtained in this work are similar to that reported (14) who recorded 85.56 % for Lohman Silver type, but lower value from that of Fayoumi (91.3 %). Lower values of hatchability were reported in Marshall breed (74.22 %) by (15). There was significant ($P < 0.05$) effect of genotype on EEM and LEM between the Marshall (8.86

and 7.41%) and Arbor acre (8.61 and 10.32 %), respectively. (16) reported 2.20, 3.90 and 8.40 % for EEM and LEM in Frizzle, Naked neck and Anak Titan indigenous chickens which are lower than those value of EEM and LEM observed in this study.

Age had significant ($P < 0.05$) effect of on fertility, hatchability and embryonic mortalities. Fertility and hatchability increased as age increased while reverse case was observed in mortalities and this could be attributed to physiological changes that take place in the hen as they increase in age. For maximum productivity, hatcheries are encouraged to make more production during the ages of 44-52 weeks so as to maximize profit and cover up the low fertility they may incurred at younger ages. The finding was in line with the report of (17) who observed that age of a hen had influence on fertility, hatchability and embryonic mortality and this may be due to the arrangement of ovarian large yellow follicles changing with photo stimulation age (18). (19) also reported similar findings (increase in fertility and hatchability with age). (20) reported similar finding on embryonic mortality in poultry, while (21) reported contrary to the findings in this study.

Season had significant ($P < 0.05$) effect on all traits, which showed that fertility and hatchability thrives better in the dry – cold climatic condition, followed by rainy season, then dry – hot season, respectively. The higher rate of fertility and hatchability could be attributed to drop in temperature which is favorable for hormonal balance, yielding high proportion of fertile egg due to absence of heat stress. The finding of this study is in agreement with the work of (22) and (23) where they reported variation in fertility and hatchability among seasons.

The effect of genotype, age and season on external egg quality is presented on Table 2. Genotype had no significant effect on the traits, while age and season had significant effect on all traits, except season in egg shape index. The effect of genotype on egg weight (EW), egg length (EL), egg width (EWD) and egg shape index (ESI) were not significant ($P > 0.05$) between Marshall and Arbor acre. The result of this study is similar to those of (24) who reported egg weight of 58.38 g in Leghorn, 55.95g in Rhode Island Red, 56.3g in Barred Plymouth Rock and 59.60g in White Rock, respectively. (25) also reported values that differs from the ones recorded in this study in Rhode Island Red (53.8g) and White Leghorn (58.69g), respectively. Lower value was reported by (26) of 58.3g in Shika Brown, as well as (27) who reported 57.7g in Ross; and (28) who reported 59g in Cobb broiler breeder. Lower value was also recorded in Shaver Brown as 51.75g (29).

(30) reported higher values of egg weight 60.96 g in Oravca and 57.60 g in Rhode Island Red, respectively. Higher value of 78 g was also recorded in ISA Brown, as reported (31). The findings of this study as compared with other authors indicated that both genotypes under the study performed well and have expressed their optimum genetic potentials. This implies that both genotypes have adapted well to this environment and can therefore be recommend for use where heavier egg weight is a choice. As egg weight

Table 1: Least Square Means and Standard Errors of Reproductive Traits in Marshall and Arbor Acre Breeding Stocks as Affected by Genotype, Age and Season

Parameters (%)	Fertility	Hatchability	EEM	LEM
Overall mean	88.09±0.33	82.60±0.69	7.84±0.27	9.81±0.38
Genotype	ns	ns	*	*
Marshall	88.22±0.51	83.40±1.86	8.86±0.31^{a}	8.61±0.65^{b}
Arbor acre	88.04±0.42	82.26±0.58	7.41±0.36^{b}	10.32±0.46^{a}
Age (weeks)	*	*	***	*
26-34	82.71±0.56^{c}	77.48±0.71^{c}	8.96±0.30^{a}	15.77±0.43^{a}
35-43	88.32±0.27^{b}	82.31±0.62^{b}	7.79±0.65^{b}	10.50±0.38^{b}
44-52	91.46±0.20^{a}	86.31±1.51^{a}	7.16±0.22^{b}	5.14±0.21^{c}
Season	*	*	***	*
Dry Cold	91.46±0.20^{a}	86.31±1.51^{a}	7.16±0.22^{b}	5.14±0.21^{c}
Dry Hot	81.78±0.37$_{c}$	75.52±0.71^{c}	9.55±0.39^{a}	16.44±0.61^{a}
Rainy	87.15±0.40^{b}	81.59±0.55^{b}	7.93±0.50^{b}	11.65±0.39^{b}

EEM = early embryonic mortality and LEM = late embryonic mortality. ^{a,b,c}… Means within the same row within a subset bearing superscripts differ significantly (P < 0.005), SEM: Standard error of mean; NS: not significant (P > 0.05); *: significant (P < 0.05); **: Significant (P < 0.01) and ***: significant (P < 0.001).

Table 2: Least Square Means and Standard Error of External Egg Quality of Marshall and Arbor Acre Breeding Stocks

Parameters (%)	EW(g)	EL (cm)	EWD (cm)	E.S.I (%)
Overall mean	63.22±0.99	4.55±0.22	3.23±0.02	70.78±0.53
Genotype	Ns	Ns	Ns	Ns
Marshall	62.59±1.68	4.56±0.03	3.21±0.03	70.59±0.73
Arbor acre	63.85±1.07	4.54±0.03	3.22±0.04	71.00±0.077
Age (weeks)	*	**	**	**
26-34	56.42±0.79^{c}	4.54±0.04^{a}	3.14±0.03^{b}	69.83±0.88^{b}
35-43	65.87±0.52^{b}	4.67±0.03^{a}	3.29±0.05^{a}	70.43±1.02^{a}
44-52	68.94±1.65^{a}	4.51±0.03^{b}		72.21±0.79^{a}
Season	*	**	**	ns
Dry hot	53.20 ±0.61^{c}	4.32±0.03^{b}	3.10±0.03^{b}	71.77±0.68
Rainy	63.81±0.07^{b}	4.63±0.02^{a}	3.24±0.0^{a}	70.04±0.76
Dry cold	70.00±2.39^{a}	4.54±0.04^{a}	3.27±0.04^{a}	71.98±1.02

^{a,b,c}… Means within the same column bearing different superscripts differ significantly (P < 0.005), ns: not significant (P > 0.05); *: significant (P < 0.05), ** (P < 0.01) where EW= egg weight, EL=egg length, EWD=egg width, ESI=egg shape index.

affects hatchability, and post hatch survivability of the embryos. Larger eggs also signify better protection and supply of calcium and other minerals to the embryos and allow gas and water exchange between embryos and external environment.

Similarly, egg length was not significant with an overall mean of 4.55 cm this value is similar to finding of (32) who reported a value of 4.35 and 4.52 cm in FUNAAB-Alpha and ISA Brown, respectively. (24) reported higher values of egg length of 5.91, 5.71, 5.86 and 5.62 cm in Leghorn, Rhode Island Red, Barred Plymouth Rock and White Rock, respectively. (25) reported higher values in Rhode Island Red and White Leghorn as 5.41 and 5.83, respectively. Rakonjac *et al.* (33) reported higher egg length than the ones in this study in Dominant Black and Boven Nera as 5.8 and 6.00 cm, respectively. Addison *et al.* (30) reported egg length of 5.72 and 5.62 cm in Oravca and Rhode Island Red. (34) reported egg length in Pearl and Black guinea fowl as 3.75 and 4.6 cm, respectively. (35) reported of 3.85, 3.88 and 3.85cm in Black, Brown and Spotted Noiler hens, which are lower than what was reported in this study. Egg length to some extent affects egg shape index as it's a ratio of width and length, the higher the length, the lower the egg shape index. Egg length had been reported to significantly affect egg weight (36). Length of egg could be affected by the impact of compression of the isthmus wall, as egg shape is partially related to pelvic shape of the bird.

Effect of genotype on egg width was also found to be not significant with the overall mean of 3.23 cm. High values than ones recorded in this study were obtained in Leghorn, Rhode Island Red, Barred Plymouth and White Rock as 4.21, 4.13, 5.16 and 4.16 cm, respectively (24). (25) also reported higher value in Rhode Island Red (3.9 cm) and White Leghorn (4.34 cm). Meanwhile, (32) recorded a higher value of 5.71 cm in FUNAAB-Alpha and 5.67cm in ISA Brown, respectively. (30) reported egg width in Oravka and Rhode Island Red as 4.32 and 4.21cm, which is higher than the values obtained in this study. (35) reported egg width of 4.32 and 4.1 cm in Black, Brown and Spotted Noiler.

(37) reported that egg length and diameter were good predictors of egg weight, and subsequently higher weight of hatchlings. Egg width is affected by isthmus of the bird and can be considered to be affected physiological factor and eco-morphological factors. The effect of genotype on egg shape index was not significant. The overall mean of shape index was 70.78 %, while Marshall and Arbor acre were 70.59 and 71.0 %. The values obtained in this study were similar with those of (24) who reported the values of 74.10, 72.14, 71.14 and 74.10 % in White Leghorn, Rhode Island Red, Barred Plymouth and White Rock. (25) who also reported similar values in Rhode Island Red and White Leghorn as 72.62 and 74.44 %, respectively. Higher values were reported by (32) in FUNAAB-Alpha and ISA Brown as 76.28 and 79.7 %. (26) also reported higher value in Shika Brown as 75.99%. Other authors who reported higher values include: (30) reported in Oravka and Rhode Island Red as 75.71 and 74.96 %, (35) who recorded for Black, Brown and Spotted noiler hens as

73.34 and 73.0 %, (38) reported 76.45 in commercial layers, (39) reported egg shape index of 78.4 % in Lonhmann Brown. The results of this study showed that genotype effects egg shape index. Other factors include time of oviposition, egg length and width, nutrition. Egg shape index is an important egg quality to breeders due to its significance in estimating air-cell volume.

There was significant ($P < 0.05$) effect of age on egg weight, egg length egg width and egg shape index. The results show that age is a source of variation in all the external egg traits under study. Egg weight was affected most by age 1 (26-34), followed by age 2 (35-43), while the least affected was age 3 (44-45 weeks). The difference of 7.73 % was observed between age 1 and 2, 2.27 % between age 2 and 3, and 9.98 % between age 1 and 3.

The values recorded in this study are higher than those report (40) who reported 51.82, 58.03, 60.32 and 61.94g at week 22, 30, 34 and 38, as well as (41) who reported egg weight of 60.18 at week 26 but higher in week 46 as 67.52 g. (42) also reported lower values of egg weight at week 32-51 in Hy-line Brown as 62.4g. (43) also reported lower value in ISA Brown at week 25, 30, 35, 40, 45, and 50 as 48.77, 54.06, 52.89, 55.95 and 62.59 g. (33) reported egg weight similar values obtained in this study in Dominant Black and Boven Nera as 62.96 and 63.20g, respectively. (39) reported the effect of age on egg weight in Lonhmann Brown at week 21-40 and 41-60 as 57.9 and 64.2 g which is similar to the ones obtained in this study. The results of this study are in agreement with (44) who noted that excluding disease, age is a major factor affecting egg quality in birds.

Egg length was significantly affected by age ($P < 0.01$) with age 3 (44-42 weeks) mostly affected, followed by age 1 (26-34 weeks) and the least affected was age 2 (35-43 weeks). It can be deducted that from this study, egg length was favored by age 35-43 weeks with an egg length of 4.67 cm. The findings of this study are lower than ones reported by (41) 5.68 and 42.98 cm at age 26 and 46 weeks. (33) reported higher values of 5.80 cm and 6.00 cm at age 35 weeks in Dominant Black and Bovan Nera. (45) reported 5.26, 5.30 and 5.28 cm in three lines of Noilers. (35) reported similar value with the one of this study as 4.32 and 4.21cm in two commercial lines. (43) reported higher values in ISA Brown as 5.8cm compared to the one reported in this study. The report of this study is in line with (46) who stated significant effect of age on egg quality.

There was significant effect of age on egg width ($P < 0.01$). Age 1 (26-34 weeks) was mostly affected with the least egg width of 3.14, followed by age 3 (44-52 weeks) and least affected was age 2 (35-43 weeks). The findings in this study are lower than the values observed by (41) in commercial layers as 4.23 and 4.43 cm at age 26 and 46 weeks, respectively. (43) reported egg width of 4.37, 4.37 and 4.31 cm in ISA Brown, Dominant Black and Boven Nera at week 35. (35) reported egg width of 4.32 at week 30 in Rhode Island Red which is higher than the value observed in this study. (45) recorded 3.8cm in quails. The findings of this study are similar with (30) who reported significant effect of age on egg quality in Naked Neck, Frizzle and Normal local chickens. This

shows a positive relationship between egg quality and age. As a bird ages, external egg quality also improves which is the result of physiological maturity of the reproductive system and organs

A significant ($P < 0.01$) effect of age on egg shape index was observed with age 1(26-34 weeks) most affected, followed by age 2 (35-43 weeks) and the least affected was age 3 (44-52 weeks). This shows that age had a positive association with egg shape index. Egg shape index of 70 % above is considered most favorable for optimum hatchability. Age 2 (35 – 43) and 3 (44 – 45) presented excellent egg shape index, while age 1 (26 – 34) showed lower egg shape index than the recommended percentage. The finding of this study is higher than the one observed in commercial layers (62.17), reported (38). Higher values were reported by (35) in Spotted, Black and Brown Noilers as 73.00, 73.2 and 73.3%, respectively. (39) reported egg shape index of 78.4 in commercial layers, which also higher than the values observed in this study. (47) also reported higher values of 80.26 and 77.44 at week 46 and 60. (40) reported higher egg shape index of 78.71, 77.99, 77.58 and 77.39 % at week 22, 30, 34, and 38, respectively. (38) recorded 76.45% in commercial layers. The finding of this report is in line with what (33) who reported that egg quality is significantly affected by age. Egg shape index represent the volume of the egg and its constituents and authors have suggested value of 70 % and above, is suitable for hatchability (9, 48). This attributed to change in axial location of the embryo in normal-shaped egg during incubation. (40) reported that egg weight and shape index increased with age as because of increased in volume, passing through the isthmus of the oviduct makes it elongated.

There was significant ($P < 0.05$) effect of season on egg weight, egg length and weight but not on egg shape index. Table 2 showed that season 3 had the higher value on all the traits except egg shape index, followed by season 2 and the most affected was season 1. Egg weight was significantly affected by season as season 3 (dry cold) produced the heavier egg weight of 70.0g, followed by season 2 (rainy) and the lowest was at season 1(dry hot). The findings of this study suggested that the ambient temperature of dry cold season is suitable for larger egg production in the strains under study. The results of this study differed with those reported by (40) who observed egg weight of 58.92 g in dry cold. (49) reported similar value of 61.75 g in dry season. (33) reported that egg production and quality was best among ISA Brown layers at winter, which is in agreement with the findings of this study that season affect egg weight. (50) reported egg weight as 54.0, 54.9 and 51.10 in three commercial layers at summer, which were somewhat lower than the values observed in this study. The findings of this study indicated that season affects egg weight. This is possibly because hens take in more feed during cold period to regulate their body temperature which results in heavier egg weight and when the temperature is within their thermos-neutral zone, enhances and balances their hormones responsible for reproduction.

Egg length was significantly affected by season ($P < 0.01$) with season 2 and 3 (rainy

and dry cold seasons) observing similar values which were higher than season 1 (dry hot). The values obtained were lower than the one reported by Abdallah (40) who recorded egg length of 5.33 cm in rainy season and 5.63cm in cold season. (34) reported egg length of 4.6cm and 3.8cm in Pearl and Black Guinea fowl. (51) reported higher egg length in summer than in winter which corroborates with the findings of this study that season has a significant effect on egg quality.

Egg width was also significantly affected by season ($P < 0.01$) with dry cold and rainy recording similar value (3.27 and 3.24 cm), while season 1(dry hot) recorded the least. This shows a relationship between drops in temperature with better egg quality. (52) recorded egg width of 4.36 cm in rainy season and 4.38cm in cold season, respectively, which were higher than the ones observed in this study. (49) also reported higher egg width in commercial layers in summer and winter as 4.76 and 4.9 cm, respectively. (53) reported that egg quality of commercial layers tended to increase in winter in comparison to summer, this is in line with the findings of this study. (54) indicated that season is a major factor for determining egg quality in poultry.

The effect of season on egg shape index was not significant. This means that season is not a source of variation in this trait. The results of the three seasons show great similarities in the values obtained. The findings in this study are within the recommended value (70 % above) for an ideal egg shape index suitable for hatchability. (52) reported a higher egg shape index of 81 % and 78.0 % in rainy season and cold season compared with 70.04 % and 71.9 8% in this study, respectively. (55) also reported higher egg shape index of 75.0 %, (49) of 77.73 % in summer but observed similar value with the one of this study in winter (74.4%). The results in this study are in contrast with (51) who reported that season had effect on egg production and quality and (33) who observed great effect of season on egg quality of ISA Brown.

Conclusion and Recommendation

It can be concluded that age and season had significant effects on fertility, hatchability and mortality, hence, the need to adjust for these factors in making higher potential of some reproductive traits of these broiler breeder stocks. For maximum production, the best time for rearing broiler breeders' stock in the study area is during dry cold season. For profit maximization, poultry breeders and farmers should give adequate management and required nutrition during the earlier stage of growth during dry hot and rainy season in order to improve the reproductive performance and avoid mortality in these broiler breeder stocks of chicken. Both genotypes have performed optimally in the traits studied and are therefore recommended for production in the area which the study was carried out.

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