EFFECTS OF LOCATION, PLANTING METHOD, AND PLANT POPULATION ON THE PERFORMANCE OF 'DAURO' MILLET IN NIGERIA

By

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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Date 18 - 7 - 84

The above declaration is confirmed.

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CERTIFICATION

This thesis titled "EFFECTS OF LOCATION, PLANTING METHOD AND PLANT POPULATION ON THE PERFORMANCE OF 'DAURO' MILLET IN NIGERIA" by Daniel Ahen Labe meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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D E D I C A T I O N

To

my late younger brother

ATUMBA LABE

who departed this world on 11 December, 1982.

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ABSTRACT

In an attempt to extend and improve on the production of 'Dauro' millet, an investigation was conducted at two locations (Samaru-Zaria and Samaru-Kataf) using three planting methods (direct seeding, slant transplanting and upright transplanting) and three plant populations (55,000, 65,000 and 75,000 plants/ha) during the rainy seasons of 1981 and 1982. Two cultivars (Ex-Bondon and Ex-Zonkwa) were used.

The average grain yield at Samaru-Kataf, a location in the 'Dauro' producing area, was 1130 kg/ha whereas at Samaru-Zaria located outside the 'Dauro' ecology, the yield was only 35.0% of that obtained at the former location. The number and weight of heads, grain weight per head and 1000-grain weight followed similar pattern as the grain yield while the plant height and mortality were higher at Samaru-Zaria.

Direct seeding significantly increased grain yield over both transplanting methods at Samaru-Kataf location. The mean grain yield of 1319 kg/ha obtained from it was 26 and 29% higher than those obtained from the upright and slant transplantings, respectively. Although the grain yields among the planting methods at Samaru-Zaria were not statistically different the yields for direct seeding were lowest with an average of 6 and 14% lower than those from upright and slant transplanting methods, respectively. Direct seeding also resulted in the tallest plants and the highest number of tillers per plant and plant mortality at both

locations. The two transplanting methods had essentially the seme effect.

Plant populations in this study had no effect on 'Dauro' grain yield. They affected only plant mortality which increased with plant density. The two cultivars were not different from each other in the characters assessed with regard to locations, planting methods and plant populations.

Poor grain yield performance of 'Dauro' at Samaru-Zaria shows that the production of the crop outside its natural ecology might not be profitable. Unless for other reasons, the results of this study do not justify transplanting be it slant or upright. Plant population in this study had no effect on 'Dauro' grain yield.

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Chapter 1.

INTRODUCTION

'Dauro' millet is one of the three types of pearl millet (*Pennisetum typhoides* (Burm.) Stapf and Hubbard) produced in Nigeria. The other two types are 'Gero' millet and 'Maiwa' millet. 'Dauro', 'Gero' and 'Maiwa' are local (Hausa) names for the pearl millet types in Nigeria. Pearl millet is a cereal crop in the grass family, Gramineae. It is the most drought tolerant of all the cereals and is best adapted to the dry tropics of Africa and Asia where it constitutes one of the major staple food crops. In Africa, Nigeria is the leading producer of pearl millet (Anonymous, 1981).

Both 'Dauro' and 'Maiwa' are photosensitive and late-maturing and are produced in limited areas of the savanna region but 'Maiwa' is produced more extensively. The production of 'Dauro' is presently localized to the south of latitude 11^{O}N and on high altitude areas (600-950m above sea level) of the southern part of Kaduna State and the northern part of Plateau State. The whole area of its production lies largely in the Southern Guinea savanna and extends into the immediate environ of the Northern Guinea savanna (Fig.1). In contrast, 'Gero' is non-photosensitive and early-maturing and is produced more extensively throughout the savanna region of the country than both 'Dauro' and 'Maiwa'. A major distinction between 'Dauro' and both 'Gero' and 'Maiwa' is that the former is established mainly by transplanting while the latter are by direct seeding. Both

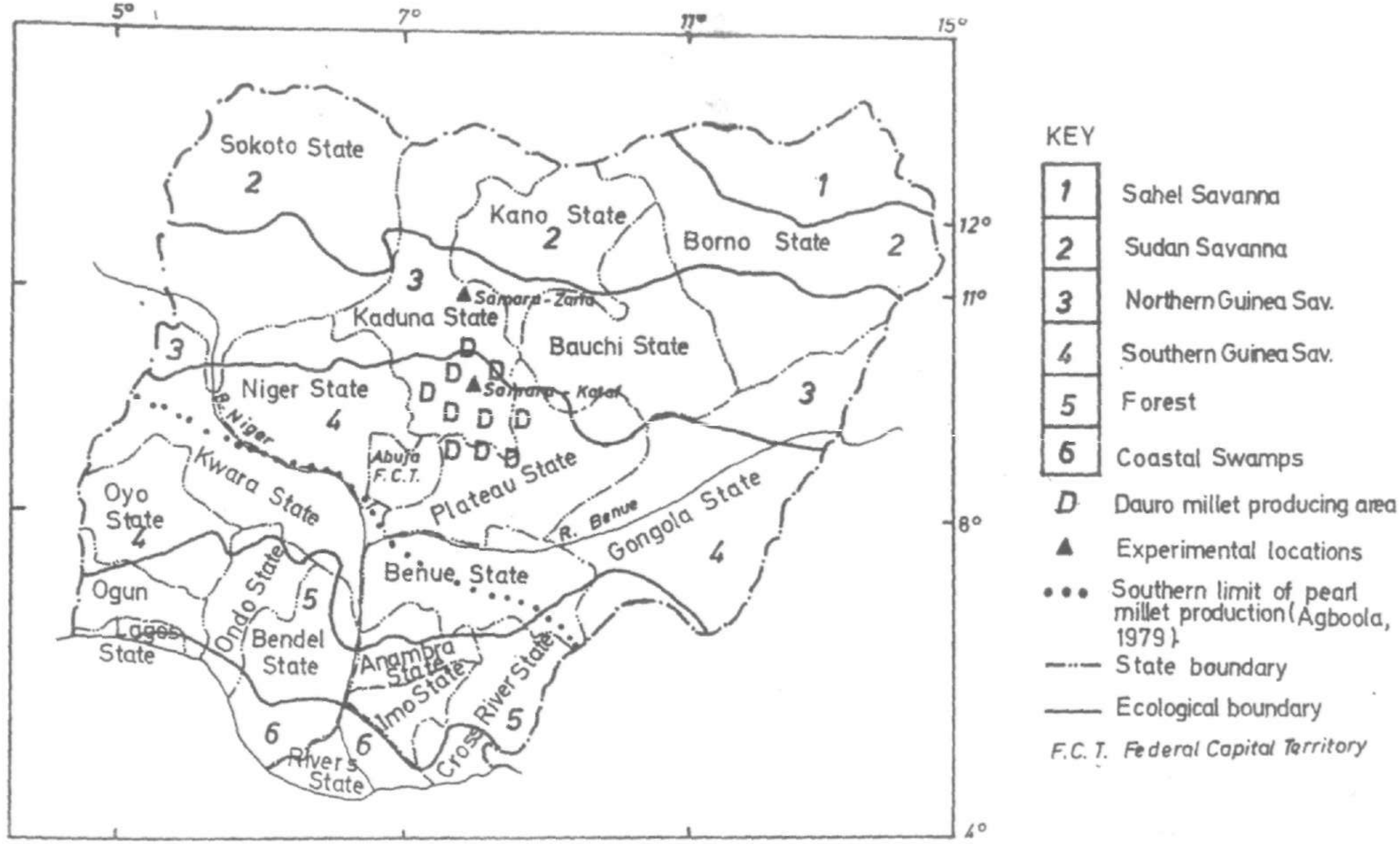

Fig.1: Area of pearl millet production and Dauro millet habitat in Nigeria.

'Gero' and 'Maiwa' are seeded directly in the field at the beginning of rainy season but 'Gero' is sown earlier. 'Dauro' is first seeded in the nursery by July to raise seedlings which are subsequently transplanted in the field by August or September. One of the advantages with transplanting is that it overcomes the problems of poor seedling emergence and the subsequent sub-optimal stand establishment which are often associated with the direct seeding in 'Gero' and 'Maiwa'. The effect of transplanting on grain yield as compared to direct seeding has never been investigated in 'Dauro', but there are reports from India that transplanting 'Bajra' millet (which is similar to 'Gero' in Nigeria) increased grain yield over direct seeding (Tomer et al., 1974; Pal, 1976; Bagga, 1979; Gurha, 1980).

'Dauro' is produced more extensively in Kaduna State than in Plateau State. This is probably connected with the historic length of time 'Dauro' has been associated with Kaduna State. According to oral history, Hausas were trading in this millet during the trade by barter. It is alleged that the Hausa millet traders had often used the phrase 'dora ni', inferring a request for assistance in lifting the load of the purchased grain on to the head. It is believed that due to the language barrier between the Hausas and the people popularly known today as the Southern Zaria people, at the time, the women selling this millet were using the word 'dora' to call the attention of the Hausa millet traders. So frequent was the word 'dora' used in the sale transactions of this millet that 'dora' eventually became the name for this type of pearl millet as 'Dauro'.

Where 'Dauro' is produced in both states, it is one of the most important cereal food crops. It is consumed as delicacy, especially in the southern part of Kaduna State known as Southern Zaria. Some of the local dishes prepared from 'Dauro' grain are 'tuwo' (thick porridge), 'akamu' (palp), 'kunu' (soft drink) and 'fura'. 'Dauro' is said to be the best millet for 'fura'. The demand for its grain extends beyond the boundary of its area of production. 'Dauro' is usually grown after groundnuts either during the same cropping season or in the following season. Consequently, the field fertilization of 'Dauro' is achieved generally by this cropping sequence. Late planting of 'Dauro' also gives the advantage of the field carrying two crops with separate growth cycles per cropping season. This also saves the labour which could have been used in clearing a new piece of land for the cultivation of 'Dauro'.

Considering the local importance of 'Dauro', a study aimed at improving its yield was conducted with the following objectives:

(1) To determine whether 'Dauro' could be successfully produced outside its present ecological area.

(2) To determine the rationale in transplanting 'Dauro' millet.

(3) To determine the effect of plant populations on 'Dauro' grain yield.

Chapter 2.

LITERATURE REVIEW

The production of 'Dauro' millet is localized and besides, very little work has been done on the crop. Consequently, no information about the crop is available in literature. In view of lack of information on 'Dauro' millet per se, the literature review is based on cultural and management aspects which are common to those documented in other types of pearl millet.

2.1 Land Preparation

Land preparation for the planting of 'Dauro' differs from that of both 'Gero' and 'Maiwa'. The land preparation for 'Dauro' is normally more thorough especially as it is cultivated during the most rainy period of the year. Generally, land preparation starts with well prepared nursery beds for raising seedlings and ends with well prepared ridges in the field on which the seedlings are subsequently transplanted. 'Gero' and 'Maiwa' as currently produced by the Nigerian farmers, do not get good land preparation (Egharevba, 1979). Generally, farmers plant especially 'Gero' after the first rain at the time the land is still dry for proper tillage. Since thorough land cultivation is not possible more so as the land is usually quite bare at the end of dry season, seeds are therefore planted only on the spots that are loosened by a hoe. However, in some parts of the Southern Guinea savanna ecological zone of the coutry, seeds are also broadcast and the land ploughed over with hoe.

Thorough land preparation is appropriate for 'Dauro' production since the crop is established by transplanting. This is because the roots of seedlings transplanted on a poorly prepared land might not easily penetrate the soil thereby resulting in poor establishment. Good land preparation, especially in some parts of the tropical region where heavy rainfalls cause considerable soil compaction is necessary to loosen the soil for easy root penetration of any arable crop and water infiltration and also lessen the problem of weeds. Chopart and Nicou (1976) found that good land preparation before planting pearl millet had increased the rate of root growth, maximum root depth and water use efficiency. Other investigators (Oswal and Dakshinamurti, 1976; Reddy *et al.*, 1977; Egharevba, 1979; Nicou, 1979) also reported that good land preparation in millet resulted in increased grain yields. Extending the production of 'Dauro' millet into the main 'Gero' producing area might give good yield since the latter still give good yield on such poorly prepared land.

2.2 Time of Planting

'Dauro' millet is normally planted at the time rains have been well established unlike the 'Gero' and 'Maiwa' millet. Planting millet early at the beginning of rainy season prior to the establishment of rains has been found to cause poor seedling emergence and consequently resulted in sub-optimal plant stands (Egharevba, 1978). Although early planting is one of the important factors in ensuring good yield in millet

(Koli, 1975; Tomer et al., 1976; Egharevba, 1978; Westphalen and Jacques, 1978; Bagga, 1979), it does so only when it is carried out at the time rains are established (Egharevba, 1978). Because 'Dauro' is planted at the time rains are well established, the risks of poor seedling emergence and subsequent sub-optimal plant stand establishment which are often associated with early planting in 'Gero' are eliminated. This infers that extending the production of 'Dauro' millet into the main 'Gero' producing area will give advantage over the risks connected with early planting in 'Gero'.

2.3 Methods of Planting

Pearl millet is planted by either direct seeding or transplanting. Direct seeding is accomplished by planting a few seeds in a hole and the emerged seedlings later thinned to one plant per stand. It could also be accomplished by seed broadcast especially as practised in the Tiv area of Benue State in the Southern Guinea savanna. Transplanting is accomplished by planting seedlings.

The traditional nursery practice in raising 'Dauro' seedlings is to prepare a nursery bed well manured with household refuse including droppings from chicken and goats, and the seeds broadcast thickly over the bed. The need for a well manured nursery bed in raising millet seedlings has been stressed by Siband et al. (1979). These workers showed that the translocation of stored mineral nutrients from seeds to seedlings in millet lasted for a short time thereby leaving the seedlings totally dependent on the soil for mineral nutrients. In this wise, seedling growth in soil of low fertility would consequently be adversely affected. Increasing the fertility status of nursery beds, especially with the nitrogen fertilizers, has been found to increase the millet seedling vigour and their subsequent grain yields (Bagga, 1979). Manured nursery beds have also been found to produce healthier and more vigorous seedlings in rice (Sethi, 1940; Grist, 1963). Grist (1963) found that the rice seedlings from manured nursery beds had better developed root systems and were 15 days ahead of the seedlings from the unmanured nursery beds.

'Dauro' seedlings are invariably transplanted in a slant position of about 45°. Although the production of 'Bajra' millet by transplanting has been widely reported in India (Tomer et al., 1974; Pal, 1976; Bagga, 1979; Gurha, 1980), mention has not been made of its mode of transplanting.

Several investigators have reported on the advantages of raising crops by transplanting. For example, transplanting 'Bajra' has resulted in increased grain yields compared with direct seeding (Tomer et al., 1974; Pal, 1976; Gurha, 1980). Yield advantages of transplanting over direct seeding have also been reported in rice (Ramiah, 1954; Gad El Hak, 1963; Grist, 1975). Other advantages of transplanting include offsetting the effect of low seed viability common with direct seeding and giving regular stands thereby facilitating weeding, shortening the period during which the crop occupies the land and in some cases serving as a protection against pests (Tempany, 1932; Anonymous, 1967). Gurha (1980) reported that transplanting 'Bajra' has reduced the intensity of downy mildew disease (Sclerospora graminicola) by 18.5% compared to the direct-sown controls. In view of the literature support for transplanting and the fact that the larger proportion of millet produced in Nigeria is by direct seeding, 'Dauro' was planted in three different ways to establish the effect of the traditional slant transplanting over direct seeding and upright transplanting.

2.4 Plant Population

The optimisation of plant density is an important agronomic practice that has been generally used to step up the grain production of millet. The optimum plant density for millet varies from place to place, depending on the ecological area and probably the cultivar used. While there is no documented information on 'Dauro' in this respect, Egharevba (1978) found that the grain yield in 'Gero' was increased up to 40,000 and 60,000 plants/ha in the Sudan and Northern Guinea ecological zones of Nigeria, respectively. Investigations in other parts of the world show that higher optimum plant densities for millet than those reported in Nigeria have been recorded. The optimum plant densities of 148,000 plants/ha (Malik and Sharma, 1979; Singh and Kanwar, 1979) and 175,000 plants/ha (Pal and Kaushik, 1972; De, 1974) have been reported mainly in India. If 'Dauro' would perform in similar way like the other types of pearl millet, its optimum plant densities in the Northern and Southern Guinea savannas, respectively, might not be the same hence there was a need to investigate its production at different plant populations.

2.5 Tillering Habit

The tillering habit of pearl millet varies considerably depending on the cultivar, the mode of planting and/or the plant density used. The number of tillers per plant as reported in direct-sown millet ranges between six and 40. Ramond (1968) reported 40 tillers per plant in late-maturing cultivars while six to 14 tillers per plant have been reported in some of the early-maturing cultivars in Nigeria (Bhardwaj and Webster, 1971; Egharevba, 1977b).

Very little is known of the tillering ability of 'Dauro' but as generally observed on the farmers' fields, it is poor in tillering. This is probably the consequences of raising the seedlings in nursery beds at high density and their subsequent transplanting. The plant density as it affects the number of tillers produced per plant was reported by Egharevba (1977b) in a direct-sown 'Gero' cultivar, Ex-Bornu, where the number of tillers per plant dropped from 12 at 50,000 plants/ha to six at 80,000 plants/ha. As regards the effect of transplanting tiller appearances in early-maturing millet cultivars were reported from the second to sixth week after seedling emergence (Begg, 1965; Ramond, 1968; Egharevba, 1977b) which infers that since 'Dauro' seedlings are traditionally transplanted at about five weeks old, the formation of tillers are probably tempared with. Seeding 'Dauro' directly in the field like 'Gero' might increase the number of tillers per plant and consequently improve the grain yield.

2.6 Photoperiodism and Its Agronomic Significance in Millet

The process of plant reaching anthesis in response to the relative duration of light and dark periods is referred to as photoperiodism. Types of pearl millet like 'Dauro' and 'Maiwa' in Nigeria and 'Sanio' in Senegal reach anthesis when the duration of light becomes relatively shorter than the period of darkness. On the other hand, such millet types like 'Bajra' in India, 'Gero' in Nigeria and 'Souna' in Senegal are reported to reach anthesis at any time regardless of the duration of the light (Bilquez, 1963: Burton, 1965; Bhardwaj and Webster, 1971).

The agronomic significance of photoperiodism in pearl millet includes the suitability of the photosensitive millet for forage production because it stays longer in the field than the non-photosensitive millet used for grain production (Barton, 1965; Barton and Powell, 1968; Patil *et al.*, 1978; Winter, 1979). Although 'Dauro' could be more suitable for forage production on account of its photosensitivity, it is currently being cultivated for grain production only. By raising seedlings in the nursery and transplanting them in the field later, farmers are able to reduce the long period of field occupation with the vegetative growth of 'Dauro' to a short one most suitable for grain production. Burton

(1965) also reported that delayed planting of the short-day forage millet types resulted in the shorter plants which facilitated gainful grain production. This is one of the advantages of transplanting 'Dauro' millet.

Chapter 3.

MATERIALS AND METHODS

3.1 Treatments

Field investigations involving 'Dauro' millet were conducted in 1981 and 1982 at Samaru-Zaria ($11^{o}11'$N, $07^{o}38'$E, 658m above sea level) and Samaru-Kataf ($09^{o}44'$N, $08^{o}23'$E, 833m above sea level). Samaru-Zaria is in the Northern Guinea savanna while Samaru-Kataf is in the Southern Guinea savanna.

Treatments investigated involved two 'Dauro' cultivars (Ex-Bondon and Ex-Zonkwa), three planting methods (direct seeding, slant transplanting and upright transplanting) and three plant populations (55,000, 65,000 and 75,000 plants/ha). The 'Dauro' seeds were procured from Bondon and Zonkwa villages in the southern part of Kaduna State and were accordingly named Ex-Bondon and Ex-Zonkwa.

3.2 Soils

The soils at both locations were well drained sandy loam. Tomlinson (1965) also described the soils of both areas as well drained sandy loam derived from crystalline basement complex and classified them as ferruginous tropical soil for Samaru-Zaria area and undifferentiated and weakly developed tropical soil for Samaru-Kataf area. Textural and some chemical properties of soils sampled from the two locations are shown in table 1.

Table 1: Some of the physio-chemical properties of the soil sample from the experimental sites at Samaru-Zaria and Samaru-Kataf, 1981.

Soil Composition	Samaru-Zaria	Samaru-Kataf
Textures (%):		
Sand	56.0	68.0
Silt	38.0	14.0
Clay	6.0	18.0
pH in water (1 : 1)	6.4	4.7
Total nitrogen, N (%)	0.025	0.039
Total phosphorus, P (ppm)	147.39	145.02
Organic carbon, C (%)	0.37	0.62
Exchangeable cations (meq/100g soil):		
Sodium, Na	0.05	0.05
Potassium, K	0.06	0.07
Calcium, Ca + Magnesium, Mg	1.36	1.40
Cation exchange capacity, CEC (meq/100g soil)	4.70	5.60
Base saturation (%)	31.28	27.14

3.3 Design and Plot Size

The experiment was laid out in a Randomized Complete Block design with three replications. There were gaps of 1.5m between blocks and 1.0m between plots within a block. Each gross plot was 6.0m long and 6.0m wide and net plots measured 6.0m long and 3.6m wide. The gross plot contained ten ridges of which the inner six ridges were for the net plot.

3.4 Land Preparation and Fertilizer Applications

Each experimental area was ploughed, harrowed and ridged at 60cm apart. Basal application of 65 kg N/ha as calcium ammonium nitrate and 45 kg P_2O_5/ha as single superphosphate were made before ridging. Additional 12 kg P_2O_5/ha was applied at sowing in direct seeded plots and at transplanting in transplanted plots while 30 kg N/ha and 15 kg K_2O/ha as muriate of potash were side-dressed to the entire crop at two weeks after transplanting.

3.5 Planting

The dates of planting were generally dictated by the pattern of rainfall at both locations. In each year and at each location, seeds were sown directly in the field and in the nursery on the same day on 22 June, 1981 and 21 June, 1982 at Samaru-Zaria and 6 July, 1981 and 27 July, 1982 at Samaru-Kataf. Seedlings in the direct-seeded plots were thinned to one plant per stand on the same day the seedlings from the nursery beds were transplanted on 24 July, 1981 and 28 July, 1982 at Samaru-Zaria and 13 August, 1981 and 6 September, 1982 at Samaru-Kataf. Planting was at the intra-row spacings of 30, 26 and 22cm to give 55,000; 65,000 and 75,000 plants/ha, respectively.

3.6 Weed, Insect and Bird Controls

Weeds were controlled manually by hoeing twice during the growth of each crop. Vetox 85 was sprayed at 1.12 kg a.i./ha in 255 litres of water to control the adults of spittlebugs (*Locris ruben*) and stem borers (*Acigona ignefusalis* Hamps.) in both years at Samaru-Zaria. Birds which infested the 'Dauro' grains in each year at Samaru-Zaria were scared away by human beings. There was neither insect nor bird damage on the crop at Samaru-Kataf in both years.

3.7 Data Collection

3.7.1 Meteorological data

Meteorological data collected at both locations included daily rainfall and air temperatures. While the data at Samaru-Zaria were recorded at the research farm of the Institute for Agricultural Research where the experiment was sited, those for Samaru-Kataf were recorded at Kafanchan (09°36'N, 08°18'E, 762m above sea level), about 20 km away from the experimental site.

3.7.2 Pest, disease and crop data

Stem borers (*Acigona ignefusalis* Hamps.) attacked 'Dauro' millet in both years at Samaru-Zaria but it was scored only in 1981 when the attack was substantial enough to give a meaningful statistical difference. The disease data were collected on downy mildew (Sclerospora graminicola (Sacc.) Schroet.) at Samaru-Kataf and on smut (Tolyposporium penicillariae Bref.) at both locations. Downy mildew also attacked 'Dauro' at both locations but the attack at Samaru-Zaria was not severe to be scored for statistical analysis. The crop data collected were number of tillers, plant height, plant mortality, number of harvestable heads, weight of harvestable heads, grain weight per harvestable head, 1000-grain weight as well as grain yield. Data were collected in the following ways:

Stem borer and downy mildew incidences: These were the percent attacked plants scored out of the total number of plants per net plot.

$$\text{Incidence (\%)} = \frac{\text{Number of plants attacked per net plot}}{\text{Total number of plants per net plot}} \times 100$$

Smut incidence and infection index: The incidence was scored by determining the percent smutted heads out of 50 randomly selected heads. The same heads were also used in the assessment of the infection index. The smut infection index (a measure of disease severity/intensity) of each head was scored on a percentage scale using the standard pearl millet smut severity assessment key of the IPMAT 4, ICRISAT* and the total infection index of the 50 heads was calculated.

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*IPMAT 4 – Fourth International Pearl Millet Adaptation Trial 1978.

ICRISAT = International Crop Research Institute for Semi-Arid Tropics.

$$\text{Incidence (\%)} = \frac{\text{Number of smutted heads}}{\text{50 randomly selected heads}} \times 100$$

$$\text{Infection index (\%)} = \frac{Y(1-1) + Y(2-1) + Y(3-1) + Y(4-1) + Y(5-1)}{4N} \times 100$$

Where

Y = Number of heads in each category of scale

1 = No symptoms.

2 = Smutted grains covering 1-5% of the head

3 = Smutted grains covering 6-20% of the head

4 = Smutted grains covering 21-50% of the head

5 = Smutted grains covering more than 50% of the head

N = Total number of heads.

Number of tillers per plant: Tillers were counted at six weeks after transplanting from five randomly selected plants and their mean value per plant worked out.

Plant height: This was determined by finding the mean height of five randomly selected plants at harvest. The height of each plant was measured from the ground level to the head tip of the main culm.

Plant mortality: The percent dead plants at harvest was determined out of the total number of plants counted at two weeks after transplanting.

$$\text{Plant mortality (\%)} = \frac{\text{Number of dead plants at harvest}}{\text{Total number of plants at two weeks after transplanting}} \times 100$$

Yield components and grain yield: Heads were harvested only from the net plots on 1 November, 1981 and 3 November, 1982 at Samaru-Zaria and 3 December, 1981 and 11 December, 1982 at Samaru-Kataf. Only the heads which had at least one third of their areas covered with grains were regarded as harvestable heads. All harvestablé heads for each net plot were counted, weighed and recorded accordingly for the number and weight of harvestable heads. The harvestable heads for each net plot were dried, threshed, winnowed and the grain weighed and recorded as grain yield. Grain yield per net plot was divided by the number of heads from which the grains were obtained and recorded as grain weight per harvestable head. One 1000 grains were sampled from each net plot, weighed and recorded as the 1000-grain weight.

3.8 Data Analysis

The data collected were statistically analysed as described by LeClerg *et al*. (1962). Where F value showed statistical significance, the means of such treatments were compared using the technique of Least Significant Difference (L.S.D.) at five percent level of probability.

Chapter 4.

RESULTS

4.1 Climatic Conditions

Rainfall at Samaru-Zaria totalled 1019.1mm in 1981 and 766.5mm in 1982 while at Samaru-Kataf 1247.9mm and 1220.0mm were recorded in 1981 and 1982, respectively. Out of these amounts, 726.6mm in 1981 and 556.9mm in 1982 at Samaru-Zaria and 640.4mm in 1981 and 737.3mm in 1982 at Samaru-Kataf fell between the period of sowing and harvesting (Appendices A-1 – A-4).

The mean monthly maximum and minimum air temperatures recorded during the growth periods of the crop were relatively lower than the pre-plant and post-harvest air temperatures during both years at both locations (Appendix B).

4.2 Number of Tillers

Locations had no effect on the number of tillers produced per plant (Table 2). Significantly higher number of tillers per plant was recorded from the direct seeding method than from any of the two transplanting methods in both years at Samaru-Zaria. Both transplanting methods had statistically the same number of tillers per plant. At Samaru-Kataf, statistical differences were found only in 1982. Direct seeding and slant transplanting methods had the same number of tillers per plant which were statistically higher than the number of tillers per plant from the upright transplanting

Table 2: Effects of location , planting method , plant population and cultivar on the number of tillers per plant of 'Dauro' millet.

Treatments	Samaru-Zaria			Samaru-Kataf		
	1981	1982	Mean	1981	1982	Mean
Planting Methods						
Direct seeding	1.8	3.0	2.4	2.7	1.6	2.2
Slant transplanting	1.1	2.2	1.7	2.3	1.6	2.0
Upright transplanting	1.2	1.9	1.6	2.3	1.3	1.8
S.E. ±	0.07	0.23	0.11	0.17	0.09	0.10
L.S.D. (P = 0.05)	0.19	0.64	0.30	NS	0.25	NS
Plant populations (plants/ha)						
55,000	1.3	2.3	1.8	2.2	1.6	1.9
65,000	1.4	2.3	1.9	2.6	1.3	2.0
75,000	1.3	2.5	1.9	2.6	1.5	2.1
S.E. ±	0.07	0.23	0.11	0.17	0.09	0.10
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Cultivars						
Ex-Bondon	1.4	2.5	2.0	2.5	1.6	2.1
Ex-Zonkwa	1.3	2.2	1.8	2.4	1.4	1.9
S.E. ±	0.06	0.19	0.09	0.14	0.07	0.08
L.S.D. (P = 0.05)	NS	NS	NS	NS	0.19	NS
Means of years	1.4	2.4		2.5	1.5	
S.E. ±	0.09			0.08		
Means of locations			1.9			2.0
S.E. ±				0.06		

The following abbreviations are applicable to this table and other subsequent tables:

NS - Not Significant; S.E. - Standard Error; LSD (P= 0.05) - Least Significant Difference at 5% level.

method. Plant populations had no effect on the number of tillers per plant at both locations. Generally, the cultivar Ex-Bondon produced higher number of tillers per plant than Ex-Zonkwa but only at Samaru-Kataf in 1982 was a statistical difference recorded.

Treatment interactions did not exert significant effect on the number of tillers per plant. On year effect, the number of tillers per plant increased significantly in 1982 at Samaru-Zaria while at Samaru-Kataf, a significant decrease was recorded in the same year.

4.3 Plant Height

The mean plant height at Samaru-Zaria was significantly higher than at Samaru-Kataf (Table 3). Plants from the direct seeding method were generally taller than those from either the slant or upright transplanting method in both years and locations but only in 1982 at Samaru-Kataf were differences in height significant. Plants from both transplanting methods had statistically the same height but those from the slant transplanting method were taller. Neither plant populations nor cultivars had effect on plant height.

There were significant interaction effects on plant height involving cultivars and planting methods at Samaru-Kataf in 1981 and cultivars and plant populations at Samaru-Zaria. Ex-Bondon produced significantly shorter plants when transplanted in a slant position than when it was either seeded directly or transplanted in an upright position (Table 4). The plant height of Ex-Zonkwa increased significantly up to 65,000

Table 3: Effects of location, planting method, plant population and cultivar on the plant height (m) of 'Dauro' millet.

Treatments	Samaru-Zaria 1981	Samaru-Zaria 1982	Samaru-Zaria Mean	Samaru-Kataf 1981	Samaru-Kataf 1982	Samaru-Kataf Mean
Planting Methods						
Direct seeding	2.91	3.32	3.12	3.05	2.85	2.95
Slant transplanting	2.86	3.26	3.06	2.95	2.42	2.69
Upright transplanting	2.77	3.29	3.03	3.05	2.27	2.66
S.E. ±	0.07	0.06	0.04	0.06	0.06	0.04
L.S.D. (P = 0.05)	NS	NS	NS	NS	0.17	0.11
Plant populations (plants/ha)						
55,000	2.76	3.22	2.99	3.02	2.60	2.81
65,000	2.83	3.37	3.10	2.99	2.49	2.74
75,000	2.95	3.28	3.12	3.05	2.45	2.75
S.E. ±	0.07	0.06	0.04	0.06	0.06	0.04
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Cultivars						
Ex-Bondon	2.77	3.30	3.04	3.02	2.54	2.78
Ex-Zonkwa	2.92	3.26	3.09	3.01	2.48	2.75
S.E. ±	0.06	0.05	0.03	0.05	0.05	0.03
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Means of years	2.85	3.27		3.02	2.51	
S.E. ±	0.03			0.03		
Means of locations			3.07			2.77
S.E. ±				0.03		

plants/ha and then decreased significantly with further increase in plant density (Table 5). There were significant year effects on plant height at both locations. At Samaru-Zaria, plants were taller in 1982 than in 1981 and vice versa at Samaru-Kataf.

4.4 Plant Mortality

Plant mortality in this study refers to the difference in the number of established plants at two weeks after transplanting and those recorded at harvest.

There was significantly higher plant mortality at Samaru-Zaria than at Samaru-Kataf (Table 6). The number of dead plants recorded was significantly higher from the direct seeding than from either the slant or upright transplanting method in both years at Samaru-Zaria and in 1981 at Samaru-Kataf. There was no statistical difference in plant mortality recorded between the two transplanting methods. Compared with direct seeding, both slant and upright transplantings reduced the mean plant mortality by 11.5 and 12.1% at Samaru-Zaria and 5.5 and 5.1% at Samaru-Kataf, respectively.

Plant populations also had significant effect on the plant mortality in both years at both locations. For every increase in plant density, there was a significant increase in plant mortality except in 1982 at Samaru-Zaria where a significant difference was recorded only between 55,000 and 75,000 plants/ha. Cultivars did not have any effect on the plant mortality.

There was a significant treatment interaction in 1981 involving plant populations and planting methods at Samaru-

Table 4: Interaction effect of cultivars and planting methods on plant height (m) of 'Dauro' millet at Samaru-Kataf, 1981.

Planting Methods	Cultivars	
	Ex-Bondon	Ex-Zonkwa
Direct seeding	3.15	2.94
Slant transplanting	2.80	3.10
Upright transplanting	3.11	2.98
S.E. ±	0.08	
L.S.D. (P = 0.05)	0.22	

Table 5: Interaction effect of cultivars and plant populations on plant height (m) of 'Dauro' millet at Samaru-Zaria, 1982.

Plant populations	C u l t i v a r s	
	Ex-Bondon	Ex-Zonkwa
55,000 plants/ha	3.22	3.21
65,000 plants/ha	3.27	3.46
75,000 plants/ha	3.40	3.16
S.E. ±	0.08	
L.S.D. (P = 0.05)	0.22	

Table 6: Effects of location , planting method , plant population and cultivar on the plant mortality (%) of 'Dauro' millet.

Treatments	Samaru-Zaria 1981	Samaru-Zaria 1982	Samaru-Zaria Mean	Samaru-Kataf 1981	Samaru-Kataf 1982	Samaru-Kataf Mean
Planting Methods						
Direct seeding	24.27	26.78	25.53	16.64	18.12	17.38
Slant transplanting	14.26	13.86	14.06	7.64	16.04	11.84
Upright transplanting	15.39	11.49	13.44	9.56	14.98	12.27
S.E. ±	1.55	3.45	1.26	1.34	1.34	0.96
L.S.D. (P = 0.05)	4.30	9.56	3.49	3.71	NS	2.66
Plant populations (plants/ha)						
55,000	12.87	10.58	11.73	4.33	6.08	5.21
65,000	17.58	17.56	17.57	8.42	15.49	11.96
75,000	23.48	23.99	23.74	21.09	27.55	24.32
S.E. ±	1.55	3.45	1.26	1.34	1.34	0.96
L.S.D. (P = 0.05)	4.30	9.56	3.49	3.71	3.71	2.66
Cultivars						
Ex-Bondon	17.27	19.05	18.17	11.10	16.52	13.81
Ex-Zonkwa	18.67	15.70	17.19	11.46	16.23	13.85
S.E. ±	1.27	2.81	1.03	1.09	1.10	0.78
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Means of years	17.97	17.38		11.28	16.38	
S.E. ±	1.03			0.78		
Means of locations			17.68			13.83
S.E. ±				0.92		

Kataf. The plant mortality for each planting method increased significantly with increases in population density (Table 7). The year effect on plant mortality was significant only at Samaru-Kataf where rate of mortality was higher in 1982 than in 1981.

Table 7: Interaction effect of planting methods and plant populations on the plant mortality (%) of 'Dauro' millet at Samaru-Kataf, 1981.

Planting methods	Plant populations (plants/ha)		
	55,000	65,000	75,000
Direct seeding	5.42	12.64	31.87
Slant transplanting	3.99	9.64	15.10
Upright transplanting	3.58	8.80	16.29
S.E. ±		2.3	
L.S.D. (P = 0.05)		6.41	

4.5 Stem Borer Attack

Stem borer attack on 'Dauro' was observed only at Samaru-Zaria but only the attack in 1981 was heavy enough to be reported. There were significant effects of the planting methods and cultivars on the incidence of stem borers (Table 8). The attacks of stem borers for slant and upright transplanting were essentially the same and significantly lower than the value recorded for direct seeding. Ex-Zonkwa cultivar had a higher stem borer incidence than Ex-Bondon cultivar. Plant population had no effect on the incidence of stem borers.

Table 8: Effects of planting method , plant population and cultivar on the incidence (%) of stem borer attack on 'Dauro' millet at Samaru,-Zaria, 1981.

Cultivars x Planting methods	Plant populations (plants/ha)			Means of planting method	Means of cultivars
	55,000	65,000	75,000		
Ex-Bondon	23.86	25.42	28.19		25.82
Direct seeding	27.03	34.03	27.19	34.10	
Slant transplanting	24.57	23.00	28.70	25.81	
Upright transplanting	19.97	19.23	28.67	25.80	
Ex-Zonkwa	30.60	32.98	30.38		31.32
Direct seeding	40.83	38.70	36.83		
Slant transplanting	23.10	33.20	22.30		
Upright transplanting	27.87	27.03	32.00		
Mean	27.22	29.20	29.28		
S.E. ±		±2.08		±2.08	±1.70
L.S.D. (P = 0.05)		NS		5.77	4.71

4.6 Downy Mildew

Downy mildew infected 'Dauro' millet at both locations but only at Samaru-Kataf was the infection heavy enough to give a meaningful statistical difference and has been reported here. Among the three factors investigated, only cultivars had significant effect on the downy mildew incidence in 1982 (Table 9). The infection was more on Ex-Bondon cultivar than on Ex-Zonkwa cultivar.

There was significant treatment interaction involving cultivars and planting methods in 1982 (Table 10). For both methods of transplanting, Ex-Bondon had significantly higher incidence of downy mildew than Ex-Zonkwa.

Table 10: Interaction effect of cultivars and planting methods on the incidence (%) of downy mildew on 'Dauro' millet at Samaru-Kataf, 1982.

Planting Methods	Cultivars	
	Ex-Bondon	Ex-Zonkwa
Direct seeding	13.71	16.22
Slant transplanting	17.79	9.81
Upright transplanting	20.09	12.82
S.E. +	2.19	
L.S.D. (P = 0.05)	6.07	

Table 9: Effects of planting method , plant population and cultivar on the incidence (%) of downy mildew on 'Dauro' millet, at Samaru-Kataf.

Treatments	1981	1982	Mean
Planting Methods			
Direct seeding	18.03	14.97	16.50
Slant transplanting	17.55	13.80	15.68
Upright transplanting	20.15	16.46	18.31
S.E. ±	2.41	1.55	1.42
L.S.D. (P = 0.05)	NS	NS	NS
Plant populations (plants/ha)			
55,000	19.76	16.36	18.06
65,000	17.80	15.00	16.40
75,000	18.17	13.86	16.02
S.E. ±	2.41	1.55	1.42
L.S.D. (P = 0.05)	NS	NS	NS
Cultivars			
Ex-Bondon	20.66	17.20	18.93
Ex-Zonkwa	16.49	12.95	14.72
S.E. ±	1.97	1.26	1.16
L.S.D. (P = 0.05)	NS	3.49	3.22
Means of years	18.58	15.08	
S.E. ±	1.16		

4.7 Millet Smut

Effect of location on the smut attack cannot be correctly deduced since the second year data at Samaru-Kataf were not recorded. Among the treatments tested, only planting methods at Samaru-Zaria in 1981 had effect on the smut attack. The attack on the direct seeded plants was highest, however, it was significantly higher than only the attack on the upright transplants (Table 11). Neither plant populations nor cultivars had any significant effect on the incidence of smut at both locations. On infection index significant effect was recorded only between cultivars at Samaru-Zaria in 1981. Ex-Zonkwa had higher infection index than Ex-Bondon (Table 12). The infection index of the disease refers to the disease severity while the disease incidence is the frequency of the disease occurrence out ot a total count.

None of the treatment interactions had a significant effect on either smut incidence or its infection index. The incidence of smut at Samaru-Zaria was significantly higher in 1982 than in 1981 while the infection index in the same years showed a reverse trend.

4.8 Number of Harvestable Heads

The number of harvestable heads averaged over the two years was significantly higher at Samaru-Kataf than at Samaru-Zaria (Table 13). Planting methods had significant effect on the number of harvestable heads at both locations in 1982. The number of heads harvested was highest from the slant transplanting but statistical significance was recorded

Table 11: Effects of location , planting methods, plant population and cultivar on the incidence (%) of millet smut on 'Dauro' millet.

Treatments	Samaru-Zaria 1981	Samaru-Zaria 1982	Samaru-Zaria Mean	Samaru-Kataf 1981
Planting Methods				
Direct seeding	67.22	98.33	82.78	65.11
Slant transplanting	61.33	99.23	80.28	75.22
Upright transplanting	58.78	99.33	79.06	66.89
S.E. ±	2.23	0.59	1.12	2.88
L.S.D. (P = 0.05)	6.18	NS	NS	NS
Plant populations (plants/ha)				
55,000	63.44	99.44	81.44	70.00
65,000	64.44	98.67	81.56	67.67
75,000	59.44	98.78	79.11	69.56
S.E. ±	2.23	0.59	1.12	2.88
L.S.D. (P = 0.05)	NS	NS	NS	NS
Cultivars				
Ex-Bondon	59.92	99.48	79.70	67.19
Ex-Zonkwa	64.96	98.44	81.70	70.96
S.E. ±	1.82	0.48	0.92	2.35
L.S.D. (P = 0.05)	NS	NS	NS	NS
Means of years	62.44	98.96		69.08
S.E. ±	0.92			

Table 12: Effects of location , planting method , plant population and cultivars on the infection index (%) of millet smut on 'Dauro' millet.

Treatments	Samaru-Zaria 1981	Samaru-Zaria 1982	Samaru-Zaria Mean	Samaru-Kataf 1981
Planting Methods				
Direct seeding	23.06	15.73	19.40	23.44
Slant transplanting	20.19	17.45	18.82	22.42
Upright transplanting	21.50	17.73	19.62	22.14
S.E. ±	1.14	1.52	0.97	1.65
L.S.D. (P = 0.05)	NS	NS	NS	NS
Plant populations (plants/ha)				
55,000	21.53	17.70	19.62	23.67
65,000	22.56	16.78	19.67	21.75
75,000	20.67	16.42	18.55	22.58
S.E. ±	1.14	1.52	0.97	1.65
L.S.D. (P = 0.05)	NS	NS	NS	NS
Cultivars				
Ex-Bondon	19.85	18.15	19.00	22.13
Ex-Zonkwa	23.31	15.78	19.55	23.20
S.E. ±	0.87	1.24	0.79	1.35
L.S.D. (P = 0.05)	2.41	NS	NS	NS
Means of years	21.59	16.97		22.67
S.E. ±	0.79			

Table 13: Effects of location , planting method , plant population and cultivar on the number of harvestable heads of 'Dauro' millet per plot.

Treatments	Sāmaru-Zaria			Samaru-Kataf		
	1981	1982	Mean	1981	1982	Mean
Planting Methods						
Direct seeding	92.4	110.6	101.5	182.0	185.6	183.8
Slant transplanting	91.0	141.2	116.1	190.8	188.1	189.5
Upright transplanting	87.7	129.3	108.5	174.6	152.9	163.8
S.E. ±	4.5	4.3	3.2	9.6	9.3	6.9
L.S.D. (P = 0.05)	NS	11.9	8.9	NS	25.8	19.1
Plant populations (plants/ha)						
55,000	92.1	120.6	106.4	175.8	186.6	181.2
65,000	87.4	126.8	107.1	182.7	160.9	171.8
75,000	91.6	133.6	112.6	188.8	179.2	184.0
S.E. ±	4.5	4.3	3.2	9.6	9.3	6.9
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Cultivars						
Ex-Bondon	91.2	125.1	108.2	179.9	188.2	184.1
Ex-Zonkwa	89.6	128.9	109.3	185.0	162.9	174.0
S.E. ±	3.7	3.5	2.6	7.8	7.6	5.7
L.S.D. (P = 0.05)	NS	NS	NS	NS	21.1	NS
Means of years	90.4	127.0		182.4	175.6	
S.E. ±	2.6			5.7		
Means of locations			108.7			179.0
S.E. ±				3.19		

only between direct seeding at Samaru-Zaria and upright transplanting at Samaru-Kataf. The number of harvestable heads averaged over the two years for each planting methods at each locations also followed a similar trend as has been described for each location. Plant populations had no effect on the number of harvestable heads. Cultivars had significant effect on the number of harvestable heads only in 1982 at Samaru-Kataf where Ex-Bondon gave higher number of harvestable heads than Ex-Zonkwa.

There was no significant treatment interaction at both locations. However, the number of harvestable heads at Samaru-Zaria increased significantly by 41% in 1982 over the value in 1981.

4.9 Weight of Harvestable Heads

The mean weight of harvestable heads was significantly higher at Samaru-Kataf than at Samaru-Zaria (Table 14). Planting methods significantly affected the weight of harvestable heads in both years at Samaru-Kataf and in 1982 at Samaru-Zaria. However, in all the three cases there was no common trend of weight variation among the planting methods. When the weights of heads were averaged over the two years, there was highest weight for the slant transplanting and lowest for direct seeding at Samaru-Zaria while at Samaru-Kataf the highest weight was for direct seeding and the lowest weight for slant transplanting. Plant populations had no detectable effect on the weight of harvestable heads. Cultivars exhibited significant differences in harvestable head

Table 14: Effects of location , planting method , plant population and cultivar on the weight (kg) of harvestable heads of 'Dauro' millet per plot.

Treatments	Samaru-Zaria			Samaru-Kataf		
	1981	1982	Mean	1981	1982	Mean
<u>Planting Methods</u>						
Direct seeding	1.43	2.05	1.74	4.74	4.74	4.74
Slant transplanting	1.47	2.67	2.07	3.67	4.69	4.18
Upright transplanting	1.58	2.34	1.96	5.01	3.67	4.34
S.E. ±	0.08	0.13	0.08	0.29	0.22	0.18
L.S.D. (P = 0.05)	NS	0.36	0.22	0.80	0.61	0.50
<u>Plant populations (plants/ha)</u>						
55,000	1.63	2.29	1.96	3.93	4.70	4.32
65,000	1.44	2.51	1.98	4.87	4.19	4.53
75,000	1.41	2.26	1.84	4.62	4.21	4.42
S.E. ±	0.08	0.13	0.08	0.29	0.22	0.18
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
<u>Cultivars</u>						
Ex-Bondon	1.64	2.32	1.98	4.25	4.77	4.51
Ex-Zonkwa	1.35	2.39	1.87	4.70	3.97	4.34
S.E. ±	0.07	0.11	0.06	0.24	0.18	0.15
L.S.D. (P = 0.05)	0.39	NS	NS	NS	0.50	NS
Means of years	1.49	2.35		4.47	4.37	
S.E. ±	0.06			0.15		
Means of locations			1.93			4.42
S.E. ±				0.09		

weight at Samaru-Zaria in 1981 and at Samaru-Kataf in 1982. The harvestable heads of Ex-Bondon cultivar weighed significantly more than those of Ex-Zonkwa cultivar at both locations.

None of the treatment interactions was significant at any of the locations. However, harvestable head weight at Samaru-Zaria was significantly higher in 1982 than in 1981.

4.10 Grain Weight per Harvestable Head

The average grain weight per harvestable head over the two years was significantly higher at Samaru-Kataf than at Samaru-Zaria (Table 15). Planting methods exerted a significant effect on grain weight per harvestable head only at Samaru-Kataf in 1981. The grain weight per harvestable head for direct seeding and upright transplanting methods were statistically the same and were, respectively, significantly higher than that recorded for the slant transplanting method. Plant populations did not have any effect on grain weight per harvestable head. Cultivars had effect on the grain weight per harvestable head only at Samaru-Zaria in 1981. The grain weight per head was higher for Ex-Bondon than for Ex-Zonkwa.

There was no significant treatment interaction but there were significant year interactions involving cultivars at Samaru-Zaria and planting methods at Samaru-Kataf as found in table 15. In 1982, the grain weight per head decreased significantly in Ex-Bondon while it increased significantly in Ex-Zonkwa. Only the grain weight per head for the slant transplanting method differed significantly between the years with the grain weight in 1982 being higher.

4.11 1000-grain Weight

The average 1000-grain weight over the two years was significantly higher by 27% at Samaru-Kataf than at Samaru-Zaria (Table 16). Planting methods significantly affected the 1000-grain weight at Samaru-Kataf in 1982. The highest weight was recorded from upright transplanting followed by those from direct seeding and slant transplanting in a decreasing order, respectively. However, only the difference between the two methods of transplanting was significant. Although planting methods did not significantly affect 1000-grain weight at Samaru-Zaria in both years, the difference between the mean 1000-grain weight over the two years for upright transplanting and direct seeding attained statistical significance. Neither plant populations nor cultivars had any effect on 1000-grain weight.

No treatment interaction exerted any significant effect on 1000-grain weight. There was neither year effect on the 1000-grain weight.

4.12 Grain Yield

The mean grain yield obtained over the two years at Samaru-Zaria was only 35.8% of the yield obtained at Samaru-Kataf over the same years (Table 17). Planting methods had significant effect on 'Dauro' grain yield only at Samaru-Kataf in both years. The highest grain yield was obtained from direct seeding with slant transplanting yielding lowest in 1981 and upright transplanting in 1982. The mean grain yield over the two years from direct seeding was significantly

Table 16: Effects of location, planting method, plant population and cultivar on the 1000-grain weight (g) of 'Dauro' millet.

Treatments	Samaru-Zaria			Samaru-Kataf		
	1981	1982	Mean	1981	1982	Mean
Planting Methods						
Direct seeding	6.87	7.34	7.11	9.50	9.56	9.53
Slant transplanting	7.38	7.68	7.53	9.45	9.12	9.29
Upright transplanting	8.18	7.58	7.88	9.59	9.85	9.72
S.E. ±	0.38	0.13	0.19	0.20	0.19	0.16
L.S.D. (P = 0.05)	NS	NS	0.53	NS	0.53	NS
Plant populations (plants/ha)						
55,000	7.64	7.62	7.63	9.46	9.82	9.64
65,000	7.73	7.63	7.68	9.50	9.38	9.44
75,000	7.05	7.35	7.20	9.59	9.32	9.46
S.E. ±	0.38	0.13	0.19	0.20	0.19	0.16
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Cultivars						
Ex-Bondon	7.41	7.47	7.44	9.56	9.44	9.50
Ex-Zonkwa	7.53	7.60	7.57	7.47	9.57	9.52
S.E. ±	0.31	0.11	0.16	0.17	0.16	0.12
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Means of years	7.47	7.53		9.52	9.51	
S.E. ±	0.16			0.12		
Means of locations			7.51			9.51
S.E. ±				0.10		

Table 17: Effects of location, planting method, plant population and cultivar on the grain yield (kg/ha) of 'Dauro' millet.

Treatments	Samaru-Zaria			Samaru-Kataf		
	1981	1982	Mean	1981	1982	Mean
Planting Methods						
Direct seeding	321.5	429.1	375.3	1348.3	1289.7	1319.0
Slant transplanting	344.6	530.9	437.8	798.7	1251.2	1025.0
Upright transplanting	334.4	466.5	400.5	1133.3	960.0	1046.7
S.E. ±	30.5	36.8	23.4	134.9	65.8	73.0
L.S.D. (P = 0.05)	NS	NS	NS	374.0	182.4	202.3
Plant populations (plants/ha)						
55,000	344.6	487.0	415.8	902.0	1229.8	1065.9
65,000	303.5	498.0	400.8	1152.3	1133.6	1143.0
75,000	352.4	441.6	397.0	1226.0	1137.5	1181.8
S.E. ±	30.5	36.8	23.4	134.9	65.8	73.0
L.S.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Cultivars						
Ex-Bondon	396.1	453.9	425.0	1045.1	1277.4	1161.3
Ex-Zonkwa	270.9	497.1	384.0	1141.8	1056.5	1099.2
S.E. ±	24.9	30.1	19.1	110.2	53.7	59.6
L.S.D. (P = 0.05)	69.1	NS	NS	NS	148.8	NS
Means of years	333.5	475.5		1093.4	1167.0	
S.E. ±	19.10			59.63		
Means of locations			404.5			1130.2
S.E. ±				33.46		

higher by 26 and 29% than those from upright and slant transplanting methods, respectively. Although planting methods had no significant effect on 'Dauro' grain yield at Samaru-Zaria, the grain yields in both years followed the same general trend. The mean grain yield over the two years at this location was lowest for direct seeding and highest for slant transplanting. The mean grain yield for direct seeding was lower by 6 and 14% than those for the upright and slant transplanting methods, respectively. Plant populations did not have significant effect on grain yield. Differences in grain yield of both cultivars were significant only in 1981 at Samaru-Zaria and in 1982 at Samaru-Kataf with Ex-Bondon consistently giving higher yields.

None of the treatment interactions had any effect on grain yield. There was a significant year effect on the grain yield at Samaru-Zaria. The grain yield was 43% higher in 1982 than in 1981.

Chapter 5.

DISCUSSION

Lower grain yield was obtained when higher rainfall was recorded during the crop growth in 1981 at Samaru-Zaria whereas at Samaru-Kataf, higher grain yield was obtained in 1982 when the rainfall was also higher. Better crop growth was observed at Samaru-Zaria than at Samaru-Kataf but the grain yield was poor. The patterns of 'Dauro' growth and yield did not show that the climatic and soil conditions at both locations were solely responsible for the performance of the crop. Therefore the effect of these environmental conditions on the performance of 'Dauro' millet could not be stated with certainty.

5.1 Location

The effect of location on the vegetative aspect of 'Dauro' millet was apparent only on plant height. The average plant height at Samaru-Zaria was 30cm taller than at Samaru-Kataf. This shows that the conditions for vegetative growth of 'Dauro' plants that developed up to the reproductive phase were better at Samaru-Zaria than at Samaru-Kataf. However, these conditions might not be the same with those for the survival of the plants as higher plants mortality was recorded at the former than at the latter location. This phenomenon might be explained to mean that while the conditions for vegetative growth of 'Dauro' millet may have been better at Samaru-Zaria, those for the survival of the plants were more ample at Samaru-Kataf.

The stem borer attack on 'Dauro' was localized at Samaru-Zaria. This may have been one of the reasons why 'Dauro' millet is still not grown extensively in the Northern Guinea savanna. On the other hand the attack of downy mildew on 'Dauro' millet at Samaru-Zaria was very mild which could be interpreted to mean that it is not a major problem in the production of 'Dauro' millet unlike at Samaru-Kataf.

The number of harvestable heads obtained at Samaru-Zaria was lower than at Samaru-Kataf. This could be attributed to the stem borer attack and grain damage by birds. The stem borer attack which occurred at the reproductive stage of the crop could have destroyed some of the head-bearing culms. Ajayi (1980) has also found that the attack of stem borers on millet at late vegetative stage usually renders some heads unharvestable. The attack of quelea birds damaged and reduced the number of grains on the heads. Consequently, some of such heads fell short of the definition as harvestable heads. Harvestable heads were defined as those heads that had at least one third of their areas covered with grains. The effects of these factors show that the ecology of Samaru-Kataf is better suited for the production of 'Dauro' millet than the ecology of Samaru-Zaria.

The weight of harvestable heads, grain weight per harvestable head and 1000-grain weight were also higher at Samaru-Kataf than at Samaru-Zaria. Higher values of head weight and grain weight per head at Samaru-Kataf could be explained on the higher grain weight and the absence of grain damage by quelea birds and higher grain weight while the 1000-grain weight could be on higher grain weight only. At Samaru-Zaria where the reverse was the case, some of the harvestable heads attacked by quelea birds had less grains and consequently weighed much less. Similarly light grains resulted in lower grain weight per head. The low 1000-grain weight at Samaru-Zaria could be attributed to the effect of dry harmattan wind. This wind which has a characteristic of drying up any available soil moisture within a short period, arrived during the grain filling stage of 'Dauro' millet at Samaru-Zaria. Consequently, 'Dauro' plants were stressed and maturity hastened, the effect which gave rise to light grain being produced. At Samaru-Kataf where the grain filling stage of 'Dauro' millet preceded the arrival of the harmattan wind, heavier grains were produced. The effect of the harmattan wind on the grain weight of 'Dauro' millet as explained on the water stress agrees with that of imposed water stress at the grain filling stage of wheat (El Nadi, 1969; Surma, 1981; Datiri, 1982) Similar explanation could also be given for the weight of harvestable heads and the grain weight per head.

The average grain yield over the two years at Samaru-Zaria was only 35.8% of the average grain yield at Samaru-Kataf. The poor grain yield at Samaru-Zaria could be attributed to the light grains, low number of harvestable heads and the grain damage by quelea birds. Compared to the grain yield at Samaru-Kataf, these factors accounted for yield losses of 9.5, 23.2 and 31.5%, respectively, (Appendix C).

The reduction in grain yield at Samaru-Zaria as a result of light grains caused by deficient moisture during the grain filling stage agrees with the findings of other investigators (Kanitkar, 1944; Lahiri and Kharabanda, 1965; Phillips and Norman, 1967) who concluded that moisture deficiency at the reproductive stage of pearl millet reduces grain yield of the crop regardless of its drought resistance. The large grain yield loss due to the grain damage by quelea birds further confirms the conclusion by Crook and Ward (1968) for a quelea birds as being a very serious pest of cereals and the most destructive bird in the world. In Nigeria, quelea birds have been reported to cause large annual losses of cereals (Hitchcock, 1960; Ward, 1964). Ward (1964) cited the Lake Chad region of Nigeria where some fields of pearl millet were abandoned because of complete grain damage inspite of vigorous attempts by famrers to protect the grains. Although better vegetative growth of 'Dauro' millet was observed at Samaru-Zaria, the grain yield was however poor due mainly to the effects of quelea birds, stem borers and harmattan wind. Therefore, since the grain yield of 'Dauro' is of utmost importance, Samaru-Zaria could not be regarded as a suitable location for 'Dauro' production.

5.2 Planting Methods

More tillers were produced per plant under direct seeding than when transplanted. However, the highest average number of tillers per plant did not exceed three the basal part with soil also might have damaged some of the potential tillers.

Although planting methods had no discernible effects on plant height, a clear trend was established whereby taller plants were produced when 'Dauro' was seeded directly in the field than when transplanted. The shorter plants from transplanting could be as a result of growth retardation suffered before the transplanted plants were adequately re-established.

Plants established by direct seeding had a higher rate of plant mortality than when established by transplanting. The higher death rate of the direct seeded plants could be as a result of longer exposure to adverse field conditions. Plants raised by direct seeding were on the field for about four weeks before those transplanted.

There was lower incidence of stem borer attack on the transplanted plants than the direct seeded plants. This result could be compared with observations in rice where transplanting also served as a protection against pests more than direct seeding (Tempany, 1932; Anonymous, 1967). This is an indication that stem borer infestation in 'Dauro' millet can be minimised by transplanting. Planting methods did not significantly affect the level of downy mildew attack. This result contrasts with the report by Gurha (1980) which showed that downy mildew attack on 'Bajra' millet was significantly reduced under transplanting as compared to direct seeding.

The number of harvestable heads recorded from slant transplanting was consistently higher than those from either the upright transplanting or direct seeding in spite of the fact that higher number of tillers was recorded consistntly from direct seeding than either of the two transplanting methods. Two possible reasons why the direct seeded plants had more tillers but produced less harvestable heads could be advanced. The highest plant mortality was recorded from direct seeding and consequently the number of stands was reduced to the extent that those which survived probably had less total number of head-bearing culms compared with either of the two transplanting methods. Secondly, not all tillers recorded from direct seeding could have produced harvestable heads. Earlier studies on the viability of tillers in other types of pearl millet showed that not all tillers produced automatically resulted in harvestable heads (Ramond, 1968; Egharevba, 1977b). However, more tillers resulting in less harvestable heads in respect of Samaru-Zaria location could be further attributed to stem borer attack and grain damage by birds as explained arlier for locations. In respect of planting methods, the highest incidence of stem borer attack on the crop was from direct seeding and this could have destroyed some of the head-bearing tillers. Secondly, the direct seeded plants were ahead of the transplanted plants in development and therefore got to anthesis and formed grains earlier thereby becoming the initial target of attack for quelea birds that damaged and reduced the number of grains on the heads. Consequently, some of such heads fell short of the heads defined as harvestable.

Although planting methods had significant effect on the weight of harvestable heads since there was no common trend in the variation of head weight among the planting methods, the significant effects could not be regarded as meaningful. Planting methods had no effect on the grain weight per harvestable head and 1000-grain weight of 'Dauro' millet. Similar result has been reported in maize (Egharevba, 1977a).

Planting methods had significant effect on 'Dauro' grain yield only at Samaru-Kataf. Although the differences in grain yield among the planting methods followed no consistent trend, direct seeding gave conssistently the highest grain yields. The mean grain yield for direct seeding was 26 and 29% higher than the mean yields from the upright and slant transplanting methods, respectively which is contrary to higher grain yields reported for transplanting 'Bajra' in India (Tomer et al., 1974; Pal, 1976; Gurha, 1980). This is an indication that the grain yield of 'Dauro' millet realized from transplanting in Samaru-Kataf area can be improved by direct seeding. At Samaru-Zaria where the differences in grain yield did not attain any statistical significance, direct seeding gave consistently the lowest yields. Although yield differences at Samaru-Zaria were not statistically significant in view of the consistent trend among the planting methods, the lowest grain yield for direct seeding could be explained on four factors. First, as explained in respect of harvestable heads, the grain damage by quelea birds consequently reduced the grain yield for the direct seeded plots. Secondly, the highest incidence of stem borer attack from direct seeing also reduced the grain yield through the reduction in number of harvestable heads. Harris (1962) who reported that late-maturing millet usually suffers severe stem borer attack, concluded that stem borers are one of the major factors limiting yield in pearl millet. Thirdly, plant mortality (a measure of established plants not developing to produce grain) was highest for direct seeding. Finally, the lowest 1000-grain weights recorded for direct seeding showed how light the grains were and this could have also contributed to the low yields in direct seeding.

5.3 Plant Populations

Plant populations had significant effect only on plant mortality. A possible explanation for the increased plant mortality with population density could be the increased inter-plant competition for nutrients, space and other factors necessary for the plant survival. The narrow range of the plant populations and the increase in plant mortality with the population density were probably responsible for the lack of plant population effect on other characters of 'Dauro' millet. On the number of tillers per plant, the lack of plant population effect contrasts with what is usually reported for 'Gero' millet where the number of tillers per plant decreases as the population density increases (Egharevba, 1977b; Egharevba et al., 1983).

5.4 Cultivars and Years

The evaluation of the two cultivars of 'Dauro' millet used in this investigation did not show that both Ex-Bondon and Ex-Zonkwa cultivars were different. However, among the characters assessed, Ex-Bondon appeared to be superior over Ex-Zonkwa in the number of tillers per plants, resistance to stem borer and smut attacks, number and grain weight of harvestable heads, grain weight per harvestable head and grain yield. Although low incidence of stem borer attack on Ex-Bondon bordered on resistance this could not be said with certainty since the result was based on one year data.

The effects of years on the performance of 'Dauro' millet were not the same at both locations. Whereas the values of the characters assessed generally increased in the second year of the study at Samaru-Zaria, there were decreases at Samaru-Kataf. The decreases at Samaru-Kataf could be attributed mainly to delay in planting.

Chapter 6.

SUMMARY AND CONCLUSIONS

Investigations involving 'Dauro' millet were conducted in 1981 and 1982 rainy seasons at Samaru-Zaria and Samaru-Kataf to explore the possibility of producing the crop outside its present ecological area and also to determine the rationale in slant transplanting the crop as well as the effect of plant populations on its grain yield. Two cultivars of 'Dauro' (Ex-Bondon and Ex-Zonkwa) were seeded directly in the field while their seedlings raised in the nursery beds were transplanted in slant and upright positions at three populations (55,000, 65,000 and 75,000 plants/ha).

'Dauro' millet at Samaru-Zaria showed better vegetative growth than what was observed in its natural ecology at Samaru-Kataf. The mean plant height of 3.07m at the former compared with 2.77m at the latter location exemplifies this fact. However only an average grain yield of 405 kg/ha was realized at Samaru-Zaria compared with 1130 kg/ha at Samaru-Kataf. The poor grain yield at Samaru-Zaria was caused by light grains, low number of harvestable heads and the grain damage by quelea birds which represented 9.5, 23.2 and 31.5% yield losses, respectively, when compared with the grain yield at Samaru-Kataf.

Among the three planting methods studied, direct seeding resulted in tallest plants and highest number of tillers per plant and plant mortality. Direct seeding also resulted in highest grain yields at Samaru-Kataf while it resulted in lowest grain yields at Samaru-Zaria. Poor grain yield performance for direct seeding at Samaru-Zaria was due to stem borer and bird attacks and plant mortality. Over the two years, the mean grain yield for direct seeding at Samaru-Kataf was 26 and 29% higher than the mean yields for upright and slant transplanting, respectively, whereas at Samaru-Zaria it was 6 and 14% lower than those for upright and slant transplantings, respectively.

Planting 'Dauro' millet at the population range between 55,000 and 75,000 plants/ha did not give any agronomic advantage on either the grain yield or some of the agronomic characters investigated. Increases in plant density resulted in increases in plant mortality. There was also no statistical difference between the two cultivars evaluated although Ex-Bondon cultivar appeared superior to Ex-Zonkwa cultivar in few respects.

From the foregoing, it can be inferred that Samaru-Zaria is not a suitable location for the production of 'Dauro' millet in view of the prevailing menaces of quelea birds, stem borers and the dry harmattan wind. Except, perhaps when and where such menaces are not pronouced or where they can be effectively checked, for instance, by means other than the traditional bird scaring. In respect of planting methods, direct seeding in Samaru-Kataf area can improve 'Dauro' grain yield over transplanting. Although the opposite may be said of Samaru-Zaria area, the average grain yield over the two locations still shows that direct seeding can improve the grain yield realized from transplanting. This shows that the rationale for transplanting 'Dauro' millet might not be actually tied to higher grain yield but could be due to some other socio-economic factors such as the possibility of producing two different crops at separate intervals on the same piece of land during the same rainy season, spreading and saving labour during the rainfed cropping season. On the mode of transplanting, no yield advantage of the traditional slant transplanting could be established over the upright transplanting. Finally, plant populations in the range of 55,000 to 75,000 plants/ha had no agronomic advantage on 'Dauro' grain yield probably because the range used was too close. There is therefore a need for further investigation into population effect on 'Dauro' millet. The two cultivars used in the investigation of the three objectives were essentially the same.

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APPENDICES

Appendix A-1: Daily rainfall (mm) at Samaru-Zaria, 1981.

Date	April	May	June	July	August	Sept.
1		27.2		0.8		
2				0.8		
3		14.1			8.6	1.3
4		TR			5.4	14.5
5				14.2	2.5	0.1
6			0.6	0.5		
7						12.0
8		1.9		25.0		33.0
9						2.3
10		5.5			9.5	
11				21.0	TR	4.8
12			30.2	14.5	0.4	
13					8.8	19.4
14						
15					6.7	
16			40.5	26.2	20.7	2.7
17					27.8	11.0
18	26.2	14.0	21.8	24.0	1.9	24.4
19		20.3				
20		3.0	8.0	TR		
21				21.5	32.0	
22			24.7		3.4	0.5
23	44.8		11.8	0.4	46.7	
24			0.5	34.0		
25				7.8	2.2	
26		3.7		2.3	29.0	
27	12.8			5.6	47.6	7.3
28	12.9		15.0	41.5	21.3	
29		1.0	1.4	2.2		
30	4.0		4.5		3.0	
31				13.3	3.1	
Monthly Total	100.7	90.7	159.0	254.8	280.6	133.3

Source: Meteorological Unit, Institute for Agricultural Research, Samaru, Zaria, Nigeria.

TR - trace.

Appendix A-2: *Daily rainfall (mm) at Samaru-Zaria, 1982.*

Date	April	May	June	July	August	Sept.	October
1		TR	TR	2.9		12.2	5.5
2						5.0	
3							
4			2.5		TR		
5		6.2	5.6		5.5	29.5	
6				24.7	8.8	1.3	
7						4.9	
8				2.0	0.6		TR
9		TR	TR	21.7	19.0	19.6	40.3
10	2.3	10.5			[illegible]	3.3	
11			16.2	19.0	3.5	8.6	
12							
13					5.1	8.5	
14	5.5			45.1	7.1	0.4	
15	1.2		TR				
16	13.3	5.3	28.0	12.4	1.8		
17					28.0		
18	2.2				TR		
19	4.6					TR	
20		16.8	25.5			15.5	
21					7.4		
22	TR	11.1			52.0	8.8	
23					7.2		
24			9.0	TR	7.7	TR	
25			4.7		2.9		
26	5.6	0.2		37.0	2.3		
27	7.9						
28	0.4		22.4		5.1		
29	16.7						
30	TR	TR		1.9	26.7		
31		22.0		TR			
Monthly Total	59.7	72.1	113.9	166.7	190.7	117.6	45.8

Source: Meteorological Unit, Institute for Agricultural Research, Samaru, Zaria, Nigeria.

TR - trace.

Appendix A-3: Daily rainfall (mm) at Kafanchan, 1981.

Date	April	May	June	July	August	Sept.	October
1		2.3	8.6	2.8	27.9	3.6	2.9
2		15.0	1.5				3.7
3			13.0			35.4	
4		16.2			32.8	1.5	8.9
5		0.2	28.5	3.6	4.0	4.5	4.2
6		9.2	11.0		7.8	4.0	6.9
7		5.8	22.5	20.3		25.0	
8					2.2	1.1	
9		18.8			2.0	27.4	
10			19.5	10.0			
11		24.8				12.0	0.5
12		7.0	2.0	13.0		13.8	
13			7.4	28.3	6.5		
14				11.5	17.2	16.9	
15		13.2	2.2		4.7	2.1	8.1
16				9.4	4.8	23.8	
17			6.7	4.9			
18			2.0		33.8	1.4	
19	6.0	1.6	0.8		4.0	3.3	
20						3.5	
21		42.0	3.2	4.8	7.9		
22	36.0	15.0	71.0	2.4		1.2	
23		7.0			3.0	6.4	
24		0.1			31.2		
25		17.0		31.0	3.1		
26			14.0		0.1	1.9	
27	12.8		0.1	9.6	21.0	2.9	4.4
28	33.8	14.0	23.8	8.0	6.8	1.8	
29		12.8	36.0	6.0		4.9	
30	10.6	2.8	0.1	5.0		2.5	
31		3.2			14.9		
Monthly Total	99.2	228.0	273.9	170.6	235.7	200.9	39.6

Source : Meteorological Unit, Kaduna State Water Board, Kafanchan, Nigeria.

Appendix A-4: Daily rainfall (mm) at Kafanchan, 1982.

Date	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.
1			TR			0.7	24.8	8.0	27.0
2			25.0	27.2	12.5		0.2	24.0	
3						50.1	0.6		
4				2.0		24.3	0.2		
5				5.0	1.8	17.0	1.5	5.0	
6				2.0		3.0	1.9		
7			36.0				3.0		
8			1.0		14.2	4.0	4.7	10.2	
9			2.0	0.3	4.0	1.1	4.0	10.0	
10				5.2		2.9		0.2	
11			1.9				0.1		
12		0.2		1.1	46.4	1.4			
13		10.2	19.0			0.6			
14		11.5		14.9		20.6	2.2		
15				1.2	13.2		21.5		
16				16.0		7.2	0.2		
17			1.0	10.8		27.3		25.5	
18		30.1	2.1		4.7	76.5	15.4		
19				0.5		2.0	24.7		
20				3.0		32.6	4.9		
21		10.2			7.2	21.6	5.7		
22				17.0	3.3	32.6			
23		3.0		2.2		2.9	18.9		
24				5.2	7.2	9.4			
25					3.1	11.7			
26	16.0	0.4		5.0	14.2	1.8		8.0	
27		12.3		2.0	1.9	6.8			
28				8.0		29.6	7.9		
29				8.5	0.7		17.5		
30		19.0		12.9	4.5	24.5			
31					14.5	25.9			
Monthly Total	16.0	96.9	88.0	150.0	153.4	438.1	159.7	90.9	27.0

Source: Meteorological Unit, Kaduna State Water Board, Kafanchan, Nigeria.

TR - trace.

Appendix B: Mean Monthly Maximum and Minimum Temperatures (°C).

	Samaru-Zaria				Samaru-Kataf			
	1981		1982		1981		1982	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	28.2	11.5	29.8	13.9	*	*	31.3	19.5
February	32.4	15.4	31.0	15.1	*	*	32.5	21.6
March	34.8	18.9	34.6	19.5	*	*	33.1	21.7
April	36.0	20.1	35.7	21.5	*	*	32.4	22.4
May	31.9	20.9	33.4	21.8	31.4	18.7	29.2	21.5
June	30.7	20.5	30.9	21.0	27.9	20.1	27.7	20.6
July	28.1	19.5	29.5	19.9	26.5	20.7	25.8	18.9
August	28.4	19.5	28.0	19.5	26.3	20.1	26.9	20.5
September	30.1	19.4	29.6	19.5	26.6	20.2	27.3	19.9
October	32.5	17.3	30.9	18.7	29.1	20.5	28.1	19.4
November	29.1	14.2	30.2	12.9	31.5	22.4	30.5	14.5
December	30.3	12.7	30.2	14.0	32.9	16.2	32.9	14.4

Sources: Samaru-Zaria – Meteorological Unit, Institute for Agricultural Research, Samaru, Zaria, Nigeria.

Kafanchan – Meteorological Unit, Kaduna State Water Board, Kafanchan, Nigeria.

Max. – Maximum

Min. – Minimum

* Data not available.

Appendix C: How the figures for 'Dauro' grain yield losses due to the low number of harvestable heads, low grain weight and the grain damage by quelea birds at Samaru-Zaria were arrived at.

	Mean		
	Number of heads	1000-grain weight (g)	Grain yield (kg/ha)
Samaru-Zaria	108.7	7.51	404.5
Samaru-Kataf	179.0	9.51	1130.2

i. Yield loss due to the number of harvestable heads:

If there was a mean of 179 heads at Samaru-Zaria the grain yield would have been $\frac{404.5}{108.7}$ kg/ha x 179

= 666.1 kg/ha

∴ Yield loss = 666.1 kg/ha - 404.5 kg/ha

= 261.6 kg/ha or 23.2% of the grain yield at Samaru-Kataf.

ii Yield loss due to low grain weight:

If the 1000 grains at Samaru-Zaria had a mean weight of 9.51g, the grain yield would have been $\frac{404.5}{7.51g}$ kg/ha x 9.51g

= 512.2 kg/ha

∴ Yield loss = 512.2 kg/ha - 404.5 kg ha

= 107.7 kg/ha or 9.5% of the grain yield at Samaru-Kataf.

iii. Yield loss due to the grain damage by quelea birds:

The mean grain yield (1130.2 kg/ha) at Samaru-Kataf less the sum of the mean grain yield (404.5 kg/ha), and the mean grain yield losses due to the lower number of harvestable heads (261.6 kg/ha) and lower 1000-grain weight (107.7 kg/ha) at Samaru-Zaria gave the yield loss due to the grain damage by quelea birds. That is

1130.2 kg/ha - (404.5 + 261.6 + 107.7) kg/ha

= 1130.2 kg/ha - 773.8 kg/ha

= 356.4 kg/ha or 31.5% of the grain yield at Samaru-Kataf.

Appendix D-1: Individual analyses of variance for number of tillers per plant of 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares			
		Samaru-Zaria		Samaru-Kataf	
		1981	1982	1981	1982
Cultivars (C)	1	0.060	1.850	0.167	0.644*
Planting methods (M)	2	2.469*	5.545*	0.908	0.551*
C x M	2	0.071	1.515	0.056	0.097
Plant populations (P)	2	0.036	0.355	1.185	0.272
C x P	2	0.087	0.295	0.223	0.084
M x P	4	0.037	0.785	0.185	0.054
C x M x P	4	0.177	0.488	0.111	0.318
Error	34	0.095	0.927	0.496	0.131

Appendix D-2: Individual analyses of variance for plant height of 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares			
		Samaru-Zaria		Samaru-Kataf	
		1981	1982	1981	1982
Cultivars (C)	1	0.300	0.006	0.002	0.057
Planting methods (M)	2	0.090	0.[illegible]14	0.056	1.640*
C x M	2	0.025	0.044	0.331*	0.156
Plant populations (P)	2	0.160	0.103	0.008	0.115
C x P	2	0.015	0.222*	0.008	0.041
M x P	4	0.015	0.048	0.053	0.50
C x M x P	4	0.225	0.015	0.015	0.012
Error	34	0.095	0.058	0.054	0.069

*Denotes statistical significance at 0.05 level of probability.

Appendix D-3: Individual analyses of variance for plant mortality in 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares			
		Samaru-Zaria		Samaru-Kataf	
		1981	1982	1981	1982
Cultivars (C)	1	26.46	151.00	1.67	1.12
Planting methods (M)	2	540.34*	1219.48*	404.37*	45.80
C x M	2	43.40	175.77	51.27	35.86
Plant Populations (P)	2	508.80*	809.46*	1374.44*	2084.30*
C x P	2	20.93	1.60	40.00	2.82
M x P	4	88.54	90.59	121.45*	10.34
C x M x P	4	114.26	129.04	5.29	13.38
Error	34	43.48	60.16	32.13	32.49

* Denotes statistical significance at 0.05 level of probability.

Appendix D-4: Individual analyses of variance for stem borer incidence at Samaru-Zaria in 1981 and downy mildew incidence at Samaru-Kataf in 1981 and 1982 in 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares		
		Stem borer incidence	Downy Mildew Incidence	
			1981	1982
Cultivars (C)	1	408.38*	235.21	243.21*
Planting methods (M)	2	413.07*	34.48	31.89
C x M	2	85.61	13.70	154.60*
Plant populations (P)	2	24.30	19.61	28.09
C x P	2	37.50	11.59	7.92
M x P	4	62.90	87.98	81.33
C x M x P	4	56.54	86.53	28.03
Error	34	77.71	104.75	43.18

* Denotes statistical significance at 0.05 level of probability.

Appendix D-5: Individual analyses of variance for smut incidence in 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares		
		Samaru-Zaria		Samaru-Kataf
		1981	1982	1981
Cultivars (C)	1	342.53	14.52	192.67
Planting methods (M)	2	337.56*	5.41	5.25
C x M	2	68.96	1.41	54.90
Plant populations (P)	2	126.01	3.19	27.64
C x P	2	212.51	6.74	216.22
M x P	4	80.22	5.85	9.52
C x M x P	4	46.97	2.96	50.11
Error	34	89.84	6.27	149.55

* Denotes statistical significance at 0.05 level of probability.

Appendix D-6: Individual analyses of variance for smut infection index in 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares		
		Samaru-Zaria		Samaru-Kataf
		1981	1982	1981
Cultivars (C)	1	161.83*	75.86	15.57
Planting methods (P)	2	36.93	21.13	8.52
C x M	2	31.15	17.80	5.67
Plant populations (P)	2	16.10	7.81	16.63
C x P	2	15.59	47.87	44.93
M x P	4	32.99	25.62	3.83
C x M x P	4	16.09	3.89	23.50
Error	34	23.55	41.53	49.08

* Denotes statistical significance at 0.05 level of probability.

Appendix D-7: Individual analyses of variance for the number of harvestable heads of 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares			
		Samaru-Zaria		Samaru-Kataf	
		1981	1982	1981	1982
Cultivars (C)	1	34.24	196.46	347.60	8689.36*
Planting methods (M)	2	106.02	4289.02*	1179.05	6952.80*
C x M	2	645.35	148.69	1658.55	499.02
Plant populations (P)	2	119.91	760.96	761.40	1258.57
C x P	2	929.69	93.41	6.75	3142.30
M x P	4	189.32	258.88	2058.18	558.82
C x M x P	4	112.55	160.05	2344.08	4109.16
Error	34	364.37	332.56	1644.69	1542.27

* Denotes statistical significance at 0.05 level of probability.

Appendix D-8: Individual analyses of variance for the weight of harvestable heads of 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares			
		Samaru-Zaria		Samaru-Kataf	
		1981	1982	1981	1982
Cultivars (C)	1	1.130*	0.060	2.750	8.640*
Planting methods (M)	2	0.120	1.776*	9.010*	6.608*
C x M	2	0.340	0.041	0.090	0.190
Plant populations	2	0.275	0.323	4.240	1.511
C x P	2	0.035	0.082	0.025	1.420
M x P	4	0.075	0.251	1.053	0.601
C x M x P	4	0.060	0.392	0.660	1.491
Error	34	0.123	0.306	1.536	0.897

* Denotes statistical significance at 0.05 level of probability.

Appendix D-9: Individual analyses of variance for grain weight per harvestable head of 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares			
		Samaru-Zaria		Samaru-Kataf	
		1981	1982	1981	1982
Cultivars (C)	1	111.51*	2.28	20.41	4.33
Planting methods (M)	2	16.66	1.16	258.64*	4.80
C x M	2	18.76	17.50	81.24	7.56
Plant populations (P)	2	4.95	13.07	29.43	6.36
C x P	2	14.77	1.68	139.23	0.94
M x P	4	2.75	5.08	56.53	1.23
C x M x P	4	5.60	8.45	84.78	13.41
Error	34	8.24	7.25	54.3[illegible]	6.41

* Denotes statistical significance at 0.05 level of probability.

Appendix D-10: Individual analyses of variance for 1000-grain weight of 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares			
		Samaru-Zaria		Samaru-Kataf	
		1981	1982	1981	1982
Cultivars (C)	1	0.190	0.230	0.130	0.220
Planting methods (M)	2	7.861	0.560	0.85	2.390*
C x M	2	0.047	0.560	1.120	0.875
Plant populations (P)	2	2.528	0.475	0.085	1.355
C x P	2	5.123	0.065	0.015	0.680
M x P	4	3.795	0.480	0.595	0.893
C x M x P	4	0.144	0.468	0.140	1.770
Error	34	2.654	0.318	0.736	0.671

* Denotes statistical significance at 0.05 level of probability.

Appendix D-11: Individual analyses of variance for grain yield of 'Dauro' millet.

Source of variation	Degrees of freedom	Mean squares Samaru-Zaria 1981	Mean squares Samaru-Zaria 1982	Mean squares Samaru-Kataf 1981	Mean squares Samaru-Kataf 1982
Cultivars (C)	1	211437.7*	25172.6	126150.0	658580.2*
Planting methods (M)	2	2414.2	47742.9	1381296.0*	585075.8*
C x M	2	46113.5	44928.1	30022.9	49494.3
Plant populations (P)	2	12430.1	16073.5	518958.5	53389.6
C x P	2	26324.9	9952.6	745820.5	64151.0
M x P	4	7357.0	20738.9	480533.8	12458.3
C x M x P	4	4877.2	31373.4	250060.5	101405.8
Error	34	16790.5	24374.3	327733.2	77833.2

* Denotes statistical significance at 0.05 level of probability.

Appendix D-12: Combined analyses of variance for number of tillers per plant and plant height of 'Dauro' millet over 1981 and 1982.

Source of variation	Degrees of freedom	Mean squares			
		No.of tillers/plant		Plant height	
		Samaru-Zaria	Samaru-Kataf	Samaru-Zaria	Samaru-Kataf
Years (Y)	1	27.200*	26.700*	5.176*	6.790*
Cultivars (C)	1	1.29	0.730	0.010	0.039
Y x C	1	0.620	0.080	0.300*	0.019
Planting methods (M)	2	7.505*	1.110	0.025	0.927*
Y x M	2	0.510	0.350	0.080	0.768*
C x M	2	1.005	0.055	0.057	0.018
Plant populations (P)	2	0. 120	0.270	0.113	0.057
Y x P	2	0.275	1.185*	1.148*	0.065
C x P	2	0.040	0.110	0.212*	0.040
M x P	4	0.470	0.133	0.053	0.064
Error	86	0.475	0.361	0.052	0.065

* Denotes statistical significance at 0.05 level of probability.

Appendix D-13: Combined analyses of variance for infection of 'Dauro' millet over 1981 and 1982.

Source of variation	Degrees of freedom	Mean squares		
		Zaria-Samaru		Samaru-Kataf
		Smut incidence	Smut infection index	Downy mildew incidenece
Years (Y)	1	36007.26*	576.39*	331.10*
Cultivars (C)	1	108.00	8.06	478.38*
Y x C	1	249.04*	229.68*	0.03
Planting methods (M)	2	129.60	6.00	65.05
Y x M	2	213.37*	52.06	1.32
C x M	2	24.45	10.94	76.59
Plant populations (P)	2	68.60	14.48	42.52
Y x P	2	60.59	9.43	5.17
C x P	2	137.33	6.07	4.04
M x P	4	94.07	35.07	140.41
Error	86	45.44	33.85	72.76

* Denotes statistical significance at 0.05 level of probability.

Appendix D-14: Combined analyses of variance for plant mortality and number of harvestable heads of 'Dauro' millet over 1981 and 1982.

Source of variation	Degrees of freedom	Mean squares: Plant mortality, Samaru-Zaria	Plant mortality, Samaru-Kataf	No. of harvestable heads, Samaru-Zaria	No. of harvestable heads, Samaru Kataf
Years (Y)	1	9.69	701.81*	36300.0*	1295.1
Cultivars (C)	1	25.52	0.02	33.3	2780.6
Y x C	1	151.94	2.77	197.4	6256.4
Planting methods (M)	2	1606.90*	341.58*	415.4	6565.4*
Y x M	2	92.92	108.59*	2472.8*	1566.5
C x M	2	28.89	24.76	108.7	557.5
Plant populations (P)	2	1298.41*	3382.16*	415.4	1468.4
Y x P	2	19.84	76.57	465.5	2435.5
C x P	2	5.50	11.07	744.2	604.8
M x P	4	119.62	32.21	144.7	345.3
Error	86	57.38	32.98	366.9	1724.4

* Denotes statistical significance at 0.05 level of probability.

Appendix D-15: Combined analyses of variance for weight of harvestable heads and grain weight per harvestable head of 'Dauro' millet over 1981 and 1982.

Source of variation	Degrees of freedom	Mean squares			
		Weight of heads		Grain weight per head	
		Samaru-Zaria	Samaru-Kataf	Samaru-Zaria	Samaru-Kataf
Years (Y)	1	19.935*	0.301	0.004	27.50
Cultivars (C)	1	0.335	0.818	40.94*	2.96
Y x C	1	0.853*	10.578*	72.86*	21.79
Planting methods (M)	2	1.041*	2.969	5.45	142.91*
Y x M	2	0.853*	12.652	12.37	120.53*
C x M	2	0.202	0.021	29.08	22.93
Plant populations (P)	2	0.215	0.408	17.02	15.74
Y x P	2	0.381	5.345*	1.00	20.05
C x P	2	0.114	0.839	4.94	61.05
M x P	4	0.096	0.258	6.25	32.71
Error	86	0.211	1.214	7.50	34.15

* Denotes statistical significance at 0.05 level of probability.

Appendix D-16: Combined analyses of variance for 1000-grain weight and grain yield of 'Dauro' millet over 1981 and 1982.

Source of variation	Degrees of freedom	Mean squares			
		1000-grain weight		Grain yield	
		Samaru-Zaria	Samaru-Kataf	Samaru-Zaria	Samaru-Kataf
Years (Y)	1	0.089	0.002	544,585*	146,000
Cultivars (C)	1	0.415	0.006	45,351	104,000
Y x C	1	0.001	0.333	191,259*	680,000
Planting methods (M)	2	5.388*	1.655	35,560	967,000*
Y x M	2	3.030	0.807	14,598	999,000*
C x M	2	0.212	0.170	58,611	151,000
Plant populations (P)	2	2.592	0.444	3,544	125,000
Y x P	2	0.409	0.991	24,960	447,000
C x P	2	2.501	0.858	30,067	529,000
M x P	4	2.976	0.978	10,059	522,250
Error	86	1.339	0.794	19,705	192,035

* Denotes statistical significance at 0.05 level of probability.

Appendix D-17: Overall combined analyses of variance for some characters over both years and locations.

Source of variation	Degrees of freedom	Mean squares			
		No. of tillers per plant	Plant height	Plant mortality	No. of harvestable heads
Years (Y)	1	0.002	0.048	273.30	11940.9*
Locations (L)	1	0.680	4.978*	798.60*	266985.3*
Y x L	1	53.900*	12.017*	438.19*	25654.3*
Cultivars (C)	1	1.980*	0.009	11.93	1102.5
Y x C	1	0.560	0.171	97.84	2115.6
L x C	1	0.040	0.140	13.62	1711.4
Planting methods (M)	2	7.050*	0.750*	1753.81*	5061.6*
Y x M	2	0.450	0.274*	48.11	1068.3
L x M	2	1.565*	0.252*	254.66*	3426.1*
C x M	2	0.690	0.058	40.24	553.8
Plant populations (P)	2	0.370	0.014	4411.82*	1404.7
Y x P	2	0.575	0.129	85.58	549.1
L x P	2	0.015	0.206	268.75*	479.0
C x P	2	0.135	0.102	0.92	1318.2
M x P	4	0.110	0.046	117.31	72.1
Error	187	0.433	0.077	46.02	1100.9

* Denotes statistical significance at 0.05 level of probability.

Appendix D-18: Overall combined analyses of variance for yield characters over both years and locations.

Source of variation	Degrees of freedom	Mean squares: Weight of harvestable heads	Grain weight per harvestable head	1000-grain weight	Grain yield
Years	1	7.669*	14.21	0.030	627,000*
Locations (L)	1	337.250*	1880.35*	217.800	28,438,000*
Y x L	1	12.587*	13.30	0.060	63,000
Cultivars (C)	1	1.098	10.93	0.260	143,000
Y x C	1	2.711	7.48	0.190	75,000
L x C	1	0.054	32.99	0.170	6,000
Planting methods (M)	2	0.249	80.08*	4.665*	345,000
Y x M	2	8.969*	71.64*	0.890	614,000*
L x M	2	3.761*	68.29*	2.380	657,000*
C x M	2	0.106	31.88	0.025	151,500
Plant populations (P)	2	0.347	11.24	1.885	43,500
Y x P	2	1.527	14.33	0.355	253,500
L x P	2	0.276	21.53	1.150	85,000
C x P	2	0.756	19.58	0.270	388,000*
M x P	4	0.122	15.12	2.770	121,250
Error	187	0.855	21.58	1.099	120,941

* Denotes statistical significance at 0.05 level of probability.

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Previous Qualifications:

Institution attended	From	To	Cert./Diploma/Degree
R.C.M. Primary School Labe	1959	1960	-
N.K.S.T. Prim. School Uka	1969	1970	-
W.M. Bristow Sec.Sch. Gboko	1971	1975	W. A. S. C.
School of Basic Studies, A.B.U., Zaria	1975	1976	I. J. M. B. E.
Faculty of Agriculture, A.B.U., Zaria	1976	1979	B.Sc. (Agric.)

Post(s) Held Since the Award of First Degree

Organisation	From	To	Position
N.Y.S.C., Kwara State	1979	1980	Teacher
Ministry of Agriculture (College of Agric., Yandev), Benue State	Augt. - Nov. '80		Teacher
I.A.R., A. B. U., Zaria	1980 to date		Asst. Research Fellow

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