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RESPONSES OF UPLAND RICE TO TILLAGE, SEEDING METHOD AND SPACING IN THE INLAND VALLEY OF RAINFOREST / SAVANNA TRANSITORY ZONE OF NIGERIA

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ABSTRACT

Two field trials were conducted at Abeokuta and Ibadan with the aim of investigating the performance of upland rice (NERICA® 2) in inland valley Rainforest / Savannah transitory zone of South West Nigeria as influenced by tillage practise, seeding method and spacing. The trials were arranged in split-split plot fitted to randomised completely blocked design, replicated thrice. The main plot was tillage (minimum tillage and conventional); sub-plot was seeding method (dry dibble and transplanting) and the sub-sub plot was spacing (15 cm × 15 cm, 20 cm × 20 cm and 25 cm × 25 cm). Dry dibble had significantly more number of tillers, leaf area index and dry matter accumulation than transplanted rice at both locations. Most growth parameters, at both locations had a significant increase with increasing plant population density, except dry matter accumulation. At both locations, transplanted rice had a significant longer flowering and maturity duration than dibble method. In Abeokuta, conventional tillage had significantly longer panicle length than minimum tillage. Dry dibble method had significantly more number of panicle/m^2 at Abeokuta, while significantly more number of grains/panicle was observed at Ibadan than transplanting. Increasing plant population density significantly depressed some yield components and yield at Ibadan.

Keywords: Dry dibble, NERICA rice, plant population density, tillage

INTRODUCTION

Changes in consumption and demographic profile in most countries of West Africa have increased the demand for rice, which is a major staple food. This increase in demand far outstripped its supply, creating a deficit in rice supply. Intensification of upland rice production is constrained by several factors; abiotic and biotic. Erratic rainfall distribution calls for more diligent and conservative measures in water usage for crop production in the transitory zone of Nigeria (Giertz *et al.*, 2010). Other strategies that could be deployed include the exploration of inland valley (Windmeiger and Andriesse, 1993). This ecological niche had been reported to be rich in mineral nutrients (Ogban and Babalola, 2003) and residual moisture (Giertz, 2004) that could sustain intensive upland rice production in a sustainable manner.

One major management practise that could compromise water conservation is transplanting of rice (Gupta *et al*., 2006). It is one of the methods of establishing rice on the field. This technique is faced with lots of challenges; costs of labour (Pandey and Velasco, 2002) and longer cropping duration when compared with direct seeding method. Direct seeding is gaining prominence in most parts of rice cultivation regions because of its efficient water use by the rice and early cropping duration (Farooq *et al*., 2006; Bouman and Tuong, 2001). Despite its advantages, weed infestation (Rao *et al*., 2007), panicle sterility (Farooq *et al*., 2009) and reduced nutrient availability (Gao *et al*., 2006) for growth and development had remained serious constraints for its adoption by farmers. It had also been reported that comparatively the yield of direct seeded rice is lesser than that of transplanted rice, depending on management practise adopted (Mitchell *et al*., 2004). Sink size of rice is determined by the number of tillers and panicle per meter square. Number of tillers per meter square is determined by environmental (light intensity and temperature), metabolic (carbohydrate metabolism) (Yoshida 1973) and physiological (number of tillers/hill, number of hill/m^2, tiller rates and tillering duration) factors (Min *et al*., 2011). Direct seeded rice had been implicated in reduced leaf nitrogen concentration and enzymes responsible for nitrogen metabolism compared with transplanted rice (Min *et al*., 2011). Nitrogen plays a significant role in Rubisco activity, a rate limiting enzyme in carbon assimilation, which would have been implicated in the reduced yield experienced by directed seeded rice. Other factors suggested include number of spikelet/ panicle and panicle length that was reported to be shorter in directed seed rice due mainly to poor nutritional status encountered (Min *et al*., 2011). However, direct seeded rice is reported to positively affect panicle/m^2 and number of hills/m^2 (Min *et al*., 2011).

Ameliorative measures towards increasing the numbers of tillers/m^2 thus ensuring more sink size could be through increasing plant population density. Increasing it could increase assimilatory surface of direct seeded rice for the interception of radiant energy, but beyond optimum level could have negative consequence, since there is the possibility for competition for resources, especially light and nutrient. Soil physico-chemical properties in the inland valley could be altered though the usage of appropriate tillage practise. Puddling remains conventional tillage practise in the inland valley. Percolation loss is minimised with saturated soil profile. One major advantage of such a practise is the inhibition of weed growth (Sahid and Hussain, 1995) encountered mostly in direct seeded rice plant and the changes in nutrients status (phosphorus, iron and other micronutrients) (Wade *et al*., 1998) to sustain spikelet/panicle. Reduced oxygen in the rhizosphere would engender reduced oxidation of ammonium, thus mitigating against leaching and eventual nitrogen availability (Kirk *et al*., 1994). Little information is available in the literature concerning the effect of these management practices in concert on the performances of upland rice in the inland valley.

The objective of this study was to investigate agronomic responses of upland rice cultivated in the inland valley to tillage practises, seeding method and spacing.

MATERIALS AND METHODS

Characterisation of location and experimental sites

Two field trials were carried out at two locations; rain-fed inland valley of the Federal University of Agriculture, Abeokuta (FUNAAB), Alabata Road (latitude 7^0 15' N and longitude 3^0 25' E; and altitude 76 m above sea level), Ogun state, Nigeria and paddy F 14 plot at the research farm of the Africa Rice Centre, Ibadan station (latitude 7^0 30' N and longitude 3^0 54' E), International Institute of Tropical Agriculture (IITA), Oyo road, Ibadan, Oyo State, Nigeria. The cropping history of the site indicated that at FUNAAB, Inland valley was previously cultivated to lowland rice, while at F14, Ibadan the site was left fallow for a duration of five years before the commencement of the field trial. Total monthly rainfall range at Abeokuta during the cropping season of 2011 was 349.5 mm (July) – no rainfall (December and January of 2011 and 2012). The mean temperature ranged between 29.2 ^{0}C (March and April) – 24.5 ^{0}C (July). During the cropping season at Ibadan, total monthly rainfall ranged between 314.9 mm (August) – no rainfall (December, January of 2011 and 2012). The mean temperature range was 28.8 ^{0}C (March, 2011) – 24.5 ^{0}C (August, 2011).

The textural class of the site was determined using the USDA textural triangle. Soil particle size distribution was determined using the hydrometer method (Bouyoucus, 1962). The pH was determined (in 1: 1 soil: water) using a pH meter (glass electrode) (Mclean, 1982). The organic content of the samples was determined using wet – oxidation method. Walkey-Black Method, modify by Allison (1965). Total Nitrogen was determined using modified micro Kjeldahl digestion technique (Jackson, 1962). Available phosphorus was determined using Bray-1 (Olsen and Dean, 1965) and determined colorimetrically using the method of Murphy and Riley (1962). Exchangeable bases were extracted with Normal Ammonium acetate (1N NH_4 OA) buffered at pH7. Na^+, K^+ in the extract were determined by flame photometry while Ca^{2+} and Mg^{2+} were determined using Atomic Absorption Spectrophotometer (AAS). Total Acidity was determined using KCl as the extracting medium and the (H^+ + Al) was determined. Cation Exchange Capacity (CEC) was determined by the summation of Total Exchange Bases (TEB) and Total Acidity (TA). Preplanting soil analysis in Abeokuta indicated that the pH of the soil was close to neutral (6.95), soil organic matter was 5.88 %, with 0.25 % (total nitrogen) and 10.76 ppm (available phosphorus). The textural class of soil in Abeokuta was sandy loamy. Preplanting soil pH at Ibadan was neutral (7.05). It consisted of 6.67% of organic matter, 0.29 % total nitrogen and 18.1 ppm of available phosphorus. The textual class is the same as that of Abeokuta (sandy loamy).

Design and treatment combinations

The design for the field trials was randomised complete block design (RCBD) in split – split plot arrangement with three replicates in 2011/ 2012 cropping season. NERICA® 2, an upland variety with maturity range of between < 90 – 100 days was planted in inland valley, in Abeokuta and Ibadan simultaneously. The main plot of the trial was 33.5 m × 26.5 m consisted of tillage practises (minimum tillage and conventional tillage). The sub-plot size measured 13.5 m × 13 m consisted of seeding methods (dry direct seeding and transplanting), the sub-sub plot was 5 m × 4 m (20 m^2) consisted of spacing (15 cm x 15 cm, 20 cm × 20 cm and 25 cm × 25 cm). The net plot size was 4 m × 3m (12 m^2). Minimum tillage was imposed by turning of the soil manually (hand hoe), while conventional tillage was conducted by turning (hand hoe) and pulverising the soil into slurry (feet and hand) repeatedly (simulation of seedbed preparation by resource poor farmers). Residue of preceding crops (soybean and lowland rice) were chopped after harvest into about 10 cm lengths and returning into soil surface and left for two weeks before planting upland rice.

Cultural operations

The trials were established on 27th September 2011 at Abeokuta and 5th October 2011 at Ibadan. A dry bed nursery was established at the beginning of each rice cycle near the field. The size of the bed was 1 m × 5 m. The top soil was softened and watered. To ensure uniformity in seedling ages, rice seeds (in nursery) were sown on the date of seeding the dry direct seeded on the field and watered regularly for 3 weeks after which they were transplanted. For the direct seeded upland, three to four seeds were sown and thinned to two seedlings per stand two weeks after sowing, while two 3 weeks old seedlings were transplanted for the transplanted treatment.

Weed was managed chemically with the usage of herbicide; Riceforce® (a selective pre-emergence herbicide) with oxidiaxon as active ingredient at 0.25 kg ha^{-1} was applied on the day of sowing the direct seeded at the rate of 3 kg a.i. per hectare while OrizoPlus® (360 g of propanil and 200 g of 2, 4 -D acid a.i./litre), a selective post-emergence herbicide was applied at the average recommended rate of 10 kg a.i. per hectare at 18 DAT. Rouging of subsequent weeds and off-type rice varieties were undertaken manually during the life cycle of the rice.

Sampling and data collection

From a depth of 0-20 cm on the experimental site, thirty (30) composite soil samples were taken randomly with the use of soil auger for pre-planting soil analysis to determine their physico-chemical properties. Collected soil sample was air-dried before analysis. Ten vigorous plants per plot were randomly chosen and tagged with red rope four weeks after planting for the collection of non-destructive parameters, while plants on the border row were harvested periodically to determine destructive parameters.

The following agronomic parameters were taken at vegetative stage (49 DAP and 28 DAT for dry dibble and transplanted rice, respectively), reproductive stage (77 DAP and 56 DAT for dry dibble and transplanted rice, respectively), and maturity stage (105 DAP and 84 DAT for dry dibble and transplanted rice, respectively) except for the yield component and yield which were determined after harvest. Vegetative (Emergence count, stand count, plant height, number of tillers per hill, leaf area, leaf area index and dry matter accumulation) and reproductive growth parameters (number of panicle per metre square, panicle length, panicle weight, grains per panicle and 1000 grain weight), development parameters (days-to-50 % flowering and days-to-95 % physiological maturity) and grain yield were determined. One metre square quadrant was used 2 – 3 days before harvesting to determine number of panicles per square metre. Leaf area was determined as described by Gomez (1972), at mid tillering phase, 50 % flowering and at harvest in which the leaf area of the main culms (i.e. length × breadth) was multiplied by number of tillers per hill and by a factor of 0.67. Leaf area index was obtained by dividing leaf area per hill by area supporting the plants in a hill. Dry matter was determined from sampled hills from the gross plot from the ground level, oven dried at 70 ^{0}C to a constant weight at mid-tillering, 50 % flowering and maturity. Other parameters were determined following the standard procedure.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA), mixed model at 5 % probability level. Significant means were separated using Least Significant Difference (LSD) value. The statistical package used was GENSTAT 12th Edition. All analyses were tested for the violation of ANOVA assumption prior to analysis. Discrete data collected were transformed using square root and the transformed data were used for statistical test.

RESULTS

Effect of tillage, seeding method and spacing on growth parameters of upland rice at both locations

Tillage had no significant effect ($P > 0.05$) on all the vegetative growth parameters examined except on the number of tillers at reproductive stage (Table 1) in Abeokuta. It was observed that conventional tillage had significantly higher numbers of tillers (19.39) than number of tiller (18.56) under minimum tillage at reproductive stage of development. Vegetative growth parameters were all significantly ($P < 0.05$) affected by seeding method except leaf area and leaf index at vegetative stage of development. Stand count at establishment, hill count and plant height at all stages of growth indicated that transplanted plant had significantly higher values compared to dry dibble rice plant. However, it was observed that significantly higher values were observed for dry dibble rice compared to transplanted types for leaf area, leaf area index and shoot dry matter accumulation at all stages of crop development. Significant ($P < 0.05$) effect of spacing was observed for hill count. Increasing plant population density resulted in significant increase in hill count. Similar pattern was observed on leaf area index at all stages of growth. Conversely, it was observed that leaf area at maturity and accumulation of shoot dry matter at reproductive stage of development had significant depression with increasing plant population density. Significant interaction tillage × spacing was observed on hill count, while significant interaction of tillage × seeding method × spacing was observed on plant height at reproductive stage of development. Similar interaction was observed on leaf area and leaf area index at vegetative stages. However, at reproductive stage leaf area had significant seeding method × spacing interaction. At vegetative stage, accumulation of dry matter in the shoot had significant interaction of tillage × seeding method.

Table 1: Effects of tillage, seeding method and spacing on vegetative growth parameters of upland rice (NERICA® 2) during the late season in the inland valley at Abeokuta in 2011.

Treatments	EC (%)	Hill Count	Plant Height (cm)			Leaf Area (cm2)			Leaf Area Index			Number of tillers			Aboveground Dry weight (g)		
			Veg	Repr	Mat	Veg	Repr	Mat	Veg	Repr	Mat	Veg	Repr	Mat	Veg	Repr	Mat
Tillage																	
Minimum	42.02	500.6	37.28	46.84	95.11	337	944	1096	0.92	2.67	2.98	10	18.56	26	3.83	6.37	11.67
Conventional	43.11	510.5	38.62	49.70	94.83	351	1015	936	1.02	2.78	2.62	11	19.39	27	3.75	6.52	12.29
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.83	ns	ns	ns	ns
Seeding Method																	
Dry Dibble	85.1	479.8	32.9	43.1	91.0	369	1068	1116	1.1	2.89	3.03	11.3	22	30	4.2	7.1	13.3
Transplanted	-	531.3	43.03	53.39	98.95	319	891	916	0.9	2. 6	2.6	9.6	16	23	3.4	5.8	10.7
LSD (0.05)	-	27.73	3.00	2.56	0.85	ns	143.2	175.5	ns	0.29	0.39	1.29	1.11	2.01	0.16	0.75	1.22
Spacing (cm)																	
15 x 15	42.78	786.2	37.84	48.00	95.37	333	912	900	1.48	4.05	4.00	10	20	27	3.67	6.07	11.77
20 x 20	43.57	439.0	37.61	48.18	94.80	355	974	1069	0.89	2.43	2.67	11	18	25	3.79	6.47	12.30
25 x 25	41.35	291.5	38.39	48.63	94.75	344	1053	1079	0.55	1.69	1.73	10	19	26	3.91	6.78	11.86
LSD (0.05)	ns	27.00	ns	ns	ns	ns	ns	149.7	0.26	0.43	0.41	ns	ns	ns	ns	0.46	ns
INTERACTIONS																	
T*M	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
T*S	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
M*S	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
T*M*S	ns	ns	ns	**	ns	*	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns

*EC was determined on dry dibbled plots only at 2 WAS

KEYS: EC – Emergence count, cm – centimetre(s), cm^2 – square centimetre(s), g – gramme(s), Veg. – vegetative stage, Repr. – Reproductive stage, Mat. – Maturity stage, ns – not significant, LSD - Least significant differences of means (5 % level), T – Tillage, S - Spacing, M - Seeding method, * - significant at 5 % level, ** - significant at 1 % level.

As observed in Abeokuta, at Ibadan there was no significant ($P > 0.05$) effect of tillage practises on vegetative growth parameters examined, except on the numbers of tillers at vegetative stage of development (Table 2). Conventional tillage had significantly higher number of tillers (14) compared to minimum tillage (13). It was observed that dry dibble method had significantly higher effect on the percentage of seedling emergence, leaf area at reproductive stage, number of tillers and dry matter accumulation of shoot at all stages of investigation compared to transplanting method. Significant increase in hill count and leaf area index at all stages was observed with increasing plant population density. Conversely, a significant depression in leaf area at maturity, shoot dry mass at vegetative and maturity stage was observed with increasing plant population density. Significant interaction of tillage × seeding method × spacing was observed on percentage emergence count, plant height at all stages except at maturity and leaf area and leaf area index at vegetative stages. Significant tillage × seeding method and tillage × spacing was observed on shoot dry matter accumulation at vegetative stage.

Effect of tillage, seeding method and spacing on development parameters of upland rice at both locations

Tillage and spacing had no significant ($P > 0.05$) effect on development parameters at both locations (Table 3). Transplanted rice plants had significantly longer duration to attain 50% flowering (76 days), matured longer (101 days) in Abeokuta. Similar pattern was observed in Ibadan. No significant interaction ($P > 0.05$) was observed on all the development parameters examined.

Effect of tillage, seeding method and spacing on yield and yield components of upland rice at both locations

There was no significant effect ($P > 0.05$) of tillage practises on the yield and yield components of upland rice in Abeokuta, except panicle length (Table 4). Conventional tillage had significantly longer panicle length (22.36 cm) compared to minimum tillage (21.60 cm). Number of panicle/ m^2 was significantly higher in dry dibble method (90) compared to transplanting (86). Spacing had no significant effect ($P > 0.05$) on all the yield components and yield. Significant interaction ($P < 0.05$) of tillage x spacing was observed on panicle length and number of panicle/m^2.

At Ibadan, tillage practice had no significant effect ($P > 0.05$) on the yield and yield components examined (Table 5). Number of grains/ panicle was observed to be significantly higher in dry dibble (100.7) method compared to transplanting (95.3). There was a significant depression in panicle weight, number of grains/panicle and grain yield with increasing plant population density. Significant interaction ($P < 0.05$) of tillage × spacing was observed on number of panicles/m^2, while significant interaction ($P < 0.05$) tillage × seeding method was observed on grain yield/hectare.

Table 3: Effects of tillage, seeding method and spacing on reproductive developmental parameters of upland rice (NERICA® 2) grown during the late season in the inland valley at both locations in 2011.

Treatments	Abeokuta		Ibadan	
	Days to 50 % Flowering	Days to 95 % Maturity	Days to 50 % Flowering	Days to 95 % Maturity
Tillage				
Minimum	71	96	71	95
Conventional	71	96	72	95
LSD (0.05)	ns	ns	ns	ns
Seeding Method				
Dry Dibble	66	92	66	90
Transplanted	76	101	77	100
LSD (0.05)	1.70	1.96	1.19	2.18
Spacing (cm)				
15 x 15	71	97	72	96
20 x 20	70	95	71	95
25 x 25	72	97	72	96
LSD (0.05)	ns	ns	ns	ns
INTERACTIONS				
T*M	ns	ns	ns	ns
T*S	ns	ns	ns	ns
M*S	ns	ns	ns	ns
T*M*S	ns	ns	ns	ns

KEY: ns – not significant, LSD - Least significant differences of means (5 % level), cm – centimetre(s), T – Tillage, S - Spacing, M - Seeding method.

Table 2: Effects of tillage, seeding method and spacing on vegetative growth parameters of upland rice (NERICA® 2) grown during the late season in the inland valley at Ibadan in 2011.

Treatments	EC (%)	Hill Count	Plant Height (cm)			Leaf Area (cm2)			Leaf Area Index			Number of tillers			Aboveground Dry weight (g)		
			Veg.	Repr.	Mat.	Veg.	Repr.	Mat.	Veg.	Repr.	Mat.	Veg.	Repr.	Mat.	Veg.	Repr.	Mat.
Tillage																	
Minimum	40.12	481.7	38.13	47.71	95.21	340	918	1077	0.93	2.60	2.92	13	22	28	3.71	6.44	10.75
Conventional	39.62	481.1	39.52	49.69	95.15	345	980	928	1.00	2.72	2.60	14	21	25	3.48	6.42	10.91
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns	0.07	ns	ns	1	ns	ns	ns	ns	ns
Seeding Method																	
Dry Dibble	79.74	449.5	32.58	42.60	90.89	360	1026	1095	1.02	2.81	2.97	15	24	30	3.83	6.71	11.36
Transplanted	-	513.3	45.07	54.79	99.46	325	873	910	0.91	2.51	2.55	11	19	23	3.37	6.14	10.30
LSD (0.05)	-	27.11	3.89	6.57	1.98	ns	149.6	ns	ns	ns	ns	2.42	2.80	5.76	0.33	0.37	0.70
Spacing (cm)																	
15 x 15	40.27	752.5	38.63	49.67	94.76	335	898	875	1.49	3.99	3.89	13	20	26	3.43	5.79	9.76
20 x 20	39.14	414.7	38.23	47.36	95.69	335	970	1078	0.84	2.43	2.70	14	22	27	3.58	6.43	10.80
25 x 25	40.20	277.0	39.62	49.07	95.08	357	980	1054	0.57	1.57	1.69	13	22	26	3.78	7.07	11.93
LSD (0.05)	ns	28.12	ns	ns	ns	ns	ns	159.5	0.23	0.40	0.38	ns	ns	ns	0.25	ns	0.84
INTERAC-TIONS																	
T*M	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
T*S	*	*	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
M*S	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
T*M*S	*	ns	**	*	ns	*	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns

*EC was determined on dry dibbled plots only at 2 WAS

KEY: EC – Emergence count, cm – centimetre(s), cm^2 – square centimetre(s), g – gramme(s), Veg. – vegetative stage, Repr. – Reproductive stage, Mat. – Maturity stage, ns – not significant, LSD - Least significant differences of means (5 % level), T – Tillage, S - Spacing, M - Seeding method, * - significant at 5 % level, ** - significant at 1 % level.

Table 4: Effects of tillage, seeding method and spacing on reproductive growth parameters of upland rice (NERICA® 2) grown during the late season in the inland valley at Abeokuta in 2011.

Treatments	Panicle weight (g)	Panicle length (cm)	Number of Panicles/ m2	Number of grains/ panicle	1000 grain weight (g)	Harvest Index (%)	Grain Yield (t/ha)
Tillage							
Minimum	14.84	21.60	87	93	23.80	59.4	1.62
Conventional	14.59	22.36	89	92	23.61	60.2	1.76
LSD (0.05)	ns	0.67	ns	ns	ns	ns	ns
Seeding Method							
Dry Dibble	14.85	21.96	90	93	24.24	59.9	1.75
Transplanted	14.58	22.01	86	91	23.17	59.7	1.64
LSD (0.05)	ns	ns	4.00	ns	ns	ns	ns
Spacing (cm)							
15 x 15	14.56	22.01	87	93	23.57	60.5	1.68
20 x 20	14.32	21.80	87	91	24.54	59.5	1.66
25 x 25	15.28	22.13	90	93	23.01	59.5	1.75
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns
INTERACTIONS							
T*M	ns	ns	ns	ns	ns	ns	*
T*S	ns	*	*	ns	ns	ns	ns
M*S	ns	ns	ns	ns	ns	ns	ns
T*M*S	ns	ns	ns	ns	ns	ns	ns

KEY: g – gramme(s), cm – centimetre(s), m^2 – square metre (s), % - percent, t/ha – tonnes per hectare, ns – not significant, LSD - Least significant differences of means (5 % level), T – Tillage, S - Spacing, M - Seeding method, * - significant at 5 % level.

Table 5: Effect of tillage, seeding method and spacing on reproductive growth parameters of upland rice (NERICA® 2) grown during the late season in the inland valley at Ibadan in 2011

Treatments	Panicle weight (g)	Panicle length (cm)	Number of Panicles/m2	Number of grains/panicle	1000 grain weight (g)	Harvest Index (%)	Grain Yield (t/ha)
Tillage							
Minimum	12.68	21.65	92	98	23.19	62.0	1.73
Conventional	12.25	21.79	91	99	23.75	61.8	1.67
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns
Seeding Method							
Dry Dibble	12.54	21.81	96	100.7	23.70	61.8	1.70
Transplanted	12.39	21.63	87	95.3	23.24	62.0	1.70
LSD (0.05)	ns	ns	ns	5.34	ns	ns	ns
Spacing (cm)							
15 x 15	11.58	21.24	89	89	22.95	62.9	1.50
20 x 20	12.26	22.05	89	97	23.86	60.9	1.77
25 x 25	13.56	21.88	96	108	23.61	61.9	1.84
LSD (0.05)	1.04	ns	ns	5.60	ns	ns	0.26
INTERACTIONS							
T*M	ns	ns	ns	ns	ns	ns	*
T*S	ns	ns	*	ns	ns	ns	ns
M*S	ns	ns	ns	ns	ns	ns	ns
T*M*S	ns	ns	ns	ns	ns	ns	ns

KEY: g – gramme(s), cm – centimetre(s), m^2 – square metre (s), % - percent, t/ha – tonnes per hectare, ns – not significant, LSD - Least significant differences of means (5 % level), T – Tillage, S - Spacing, M - Seeding method, * - significant at 5 % level.

DISCUSSION

Intensification of upland rice production practise among resource poor farmers could be ensured through management practise among other factors. Environmental factor; water predominantly had remained a major production constraint in upland rice ecologies, especially those supported by erratic rainfall distribution in the Rainforest/ Savanna transitory zone of Nigeria. Exploration of inland valley, where residual moisture could be used to sustain upland rice growth and development, with right management practice remains a veritable strategy. Most growth parameters investigated did not significantly respond to tillage practises, except number of tillers in both locations, while in Ibadan at vegetative stage of growth leaf area index responded positively to conventional tillage compared to minimum tillage. Mechanical displacement of the soil in inland valley had been reported to alter physico-chemical properties of the soil (soil strength, bulk density and fractional distribution of the soil particles (Sharma and De Datta, 1986). This result was also observed in this trial, where prior to the cultivation of upland rice in the sequence, it was observed that comparatively Ibadan had higher organic matter and carbon and other investigated macronutrients, though with similar textural class. The availability of these macronutrients could have affected the growth of upland rice under conventional tillage at Ibadan compared to Abeokuta. Increased tiller number in cereals could increase the assimilatory surface for the interception of radiant energy for photosynthesis. One would have expected that a significantly higher leaf area index observed at Ibadan would have resulted in more accumulation of dry matter at Ibadan. However, this was not observed in this study. Other factors could have been limiting which could not be established. Such was also observed in Abeokuta, where conventional tillage had resulted in longer panicle, which could not translate into higher sink strength and grain yield. It had been reported that number of fertile spikelet per panicle plays a significant role in sink size, which is affected by soil nutritional status and rooting condition (Min *et al*., 2011).

Higher accumulation of dry matter in dry dibble seeding method compared to transplanting could be premised on the number of tillers, higher leaf area index and leaf area observed in both locations. A higher assimilatory surface could indicate interception of more radiant energy, provided the canopy architecture does not predispose it to mutual shading. Direct seeding had been reported to ensure conservation of water, with efficient usage of it (Patnak *et al*., 2011). In the absence of weed interference in both locations through the usage of herbicide, that could be a major advantage. The higher hill count observed in transplanted upland rice did not translate to higher number of tillers that could have resulted from transplant shock. Taller plant height observed in both locations for transplanted upland rice compared to direct seeded could be deduced for the longer phenological phase experienced by transplanted rice. With longer phenological phase, rice is most likely to partition more of assimilates into vegetative growth at the expense of reproductive. Similar result had been reported by Dingkuhn *et al*. (1991). Number of panicle per meter square forms an important determinant of sink strength of rice (Gravois and Helms, 1992). Direct seeding had higher number of panicle/m^2 in Abeokuta only. Similar result had been reported by Min *et al*. (2011). Number of panicle/m^2 had been observed to be linked to number of tiller (Moldenhauer and Gibbons, 2003). In this trial direct seeding had higher number of tillers compared to transplanted upland rice. Number of tiller/m^2 is dependent on temperature, light intensity, carbohydrate metabolism, hills/m^2, tillering rate and duration (Yoshida, 1973; Zhong *et al.*, 2003; Min *et al.*, 2011). Higher number of grains/ panicle at Ibadan when upland land rice was directly seeded contradicted most of the available reports that reported comparatively lower yield because of its higher panicle sterility (Farooq *et al.*, 2009). Spikelet/ panicle had been linked to the nutritional profile of the growing condition. At Ibadan, a better fertility profile of the soil prior to the cultivation of upland rice could have suggested availability of macronutrients and reduced panicle sterility.

Increasing growth response to increasing plant population density in upland rice resulted in a depressed accumulation of dry matter at both locations. This could have implied that mutual shading could have compromised photosynthetic efficiency of the crop as reflected in reduced leaf area in both locations at increasing plant population density. A reduced photosynthetic efficiency could have compromised assimilate partitioning to the sink, as indicated in reduced panicle weight and number of grains/ panicle at Ibadan, resulting in reduced grain yield/hectare with increasing population density. The pattern observed on dry matter accumulation could also be attributed to competition for other resources (water and mineral nutrients), since these factors are directly linked to growth (cellular elongation and osmotic adjustment).

CONCLUSION

Tillage practices did not differ significantly in their effect on the growth, development and grain yield of upland rice cultivated in the inland valley of the Rainforest/Savannah transitory zone of Nigeria. Foliar characters of upland rice was significantly higher in dry dibble than transplanted upland rice, conversely plant height was more in transplanted than dry dibble, with longer cropping duration. Increasing plant population density increased leaf area with a depression in yield components and yield.

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