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EVALUATION OF PLANTING METHODS FOR GROWTH AND YIELD OF "DIGANG" RICE (*Oryza sativa* L.) UNDER UPLAND CONDITION OF BAWKU, UPPER EAST REGION, GHANA

J. K. Laary[1], W. Dogbe[2], P. O. Boamah[1] and J. Agawini[3]
[1]Department of Ecological Agriculture, Bolgatanga Polytechnic, Bolgatanga, Ghana, West Africa
[2]Savanna Agricultural Research Institute (SARI), Nyankpala, Tamale, Ghana, West Africa
[3]Savanna Agricultural Research Institute (SARI), Manga, Bawku, Ghana, West Africa
E-Mail: jlaary@yahoo.co.uk

ABSTRACT

Field experiments were conducted in the rainy seasons of 2010 and 2011 at the Savannah Agricultural Research Institute (SARI), experimental farms (Latitude 11°11'and 10°40'N, Longitude 0°18' W and 0°6'E), Manga, Bawku, Upper East Region, Ghana to determine the effects of planting methods on growth, development, yield and yield components of an introduced rice variety, IR12979-24-1, ("Digang") under upland conditions. The experiments were laid out in Randomized Complete Block Design (RCBD) with four replications at two separate upland locations (0.5 Km apart). The treatments comprised of four planting methods vis; Direct Seed Dibbling, Pre-germinated Seed Broadcasting, Direct Seed Drilling and Seedling Transplanting. Fertilizer dose of N.P.K. (15, 15, 15) in the form of nitrogen, phosphorus and potash was applied to the crop as basal NPK (60, 30, 30 kg/ha) and later top-dressed with 30 kg/ha nitrogen in the form of sulphate of ammonia. Results from analyzed data of both seasons showed that planting methods had significant effect on "Digang" growth, yield and yield components, but differences in years and plot locations were not significant. With the exception of seedling transplanting method, the other planting methods did not have significant effect on germination and plant height. The direct seed dibbling and direct seed drilling had better plant establishment and was significantly higher than pre-germinated seed broadcasting and seedling transplanting methods. Straw dry matter yield was higher in direct seed dibbling and seedling transplanting methods, and both were significantly different from direct seed drilling and pre-germinated seed broadcasting methods. Seedling transplanting method had higher panicle count, and recorded, higher yields of 2.5 tons/ha in 2010 and 2.8 tons/ha in 2011, with an overall average yield of 2.7 tons/ha, than direct seed drilling and pre-germinated seed broadcasting. The direct seed dibbling recorded mean paddy yield of 2.5 tons/ha which was significantly higher than direct seed dibbling and pre-germinated seed broadcasting method. Among examined planting methods, the most consistent planting method and best in almost all examined parameters under individual years was the seedling transplanting method followed by direct seed dibbling method. Seedling transplanting method was not significantly different from direct dibble method in almost all parameters examined. In situations where labour is available and affordable, seedling transplanting could be chosen under upland condition, but where labour and time are limiting, it makes more economic sense to opt for direct dibbling method for "Digang" rice under upland conditions.

Keywords: "digang", rice, planting method, upland, growth, paddy yield.

INTRODUCTION

Rice (*Oryza sativa* L.) is grown successfully in regions having the necessary warmth and abundant moisture favourable to its growth, be it under lowland or upland condition. It is one of the most important and indispensable caloric cereal food crop in Ghana. Beyond providing sustenance through growing, earning income and consuming, rice plays an integral, but important cultural role in many rural communities of Ghana. For instance, products of rice plant are used for a number of purposes, such as fuel, thatching, industrial starch, artwork, and festivities (Gangwar, *et al*., 2008). Rice production in Upper East Region, especially Bawku and surrounding areas have an underpinning motives of achieving desired paddy and straw yields for above purposes and as feed source for animals. Its production therefore constitutes a major economic activity and a key source of employment for the rural farming population. As a result of the crop importance, farmers, predominately women, have scattered and small plots ranging from 0.25-2.5 acres, for its cultivation under rain fed condition. These plots are mostly located upland, along valleys and sloppy to hilly lands, with few downstream hand-dug dams. This is because, apart from limited lowlands, irrigation facilities are almost non-existence for rice production in the area. The area also has a uni-modal rainfall, and the soil belong to the broad classification group, Savanna Ochrosols, which are alluvial sandy soils, quite acidic, low inherent water holding capacity and often suffers from multiple nutrient deficiencies, especially, in nitrogen and phosphorus (MOFA, 1998). So, a cultivar growing in such areas may be considered satisfactory only if it is able to produce good yield in comparison to others at various times and in various situations (Oyewole, *et al*., 2010). An introduced rice variety, IR12979-24-1 ("Digang"), literally termed "different rice", perhaps due to its ability to give high yields under above growing conditions, is the most preferred and well adopted variety in Bawku area. A crop growing under upland condition, though need ample water, it should be able to grow

anywhere, even steep, hilly or mountain areas (Ukwungwu, *et al*., 2004), and so is "Digang".

Since its introduction in 2006 and 2007, "Digang" has been one rice variety cultivated by almost every rural household in Bawku and its surrounding areas, not only because of good yield, but its ability to intercrop and/or rotate with other cereals and legumes under upland condition. Adequate technologies in "Digang" rice production under farmers' growing conditions, to unearth its potential are not conclusive. Planting method is one of such technologies, which may differ in agro-ecologies, where soils and climatic conditions differ.

Since indigenous research is a viable resource, for developing on-farm experimental methods that promote farmer participation in adopting technologies to specific farming conditions and providing feedback on basic research needs as indicated by Lightfoot (1985), this study is farmer practice based. Drawing from farmers' practice, this research thus focused on assessing the impact of common planting methods in rice cultivation among farmers on newly introduced and adopted rice cultivar, "Digang" in Bawku areas.

In rice, the planting methods have an impact on the growth and yield besides cultivation cost and labour requirements (Sanjitha Rani and Jayakiran, 2010). Traditionally, rice is transplanted, but consistent increase in labour cost in recent times, calls for other planting methods. As a result of increased labour cost, planting systems is gradually being replaced by direct sowing in many developing countries (Dawe, 2003; Naklang, *et al*., 1996). The unavailability of information for farmers on the most adaptable planting method for a newly introduced rice variety ("Digang") in Bawku agro-ecology is a matter of great concern. Identification of appropriate planting method(s) for maximum performance and less cost in "Digang" production will boost family food security, foster rural development and sustainability in the area.

There is therefore the need to determine the most appropriate planting method in an upland condition for "Digang" rice variety in rain fed agro-ecology of Bawku and its surrounding areas. It is against this backdrop that a study was conducted to evaluate the effect of four different planting methods on growth, yield components and paddy yield of the variety with a view to ascertaining the most adapted planting method based on "Digang" rice yield and to recommend the most appropriate planting method for the rice under upland conditions of savanna agro-ecology.

MATERIALS AND METHODS

Field experiments were conducted in the rainy seasons of 2010 and 2011 at the Savannah Agricultural Research Institute (SARI), experimental farm (Latitude 11°11'and 10°40'N, Longitude 0°18' W and 0°6'E), Manga, Bawku, Upper East Region, Ghana to determine the effects of planting methods on growth, development, yield and yield components of rice variety, IR12979-24-1, ("Digang") introduced to farmers in Bawku area by SARI in collaboration with West African Rice Development Association (WARDA) in 2006 and 2007.

The experiments were laid out in Randomized Complete Block Design (RCBD) with four replications at two separate locations (0.5 Km apart) upland. The treatments comprised of four planting methods vis; Direct Seed Dibbling, Pre-germinated Seed Broadcasting, Direct Seed Drilling and Seedling Transplanting. The seed rate for direct seed dibbling was 55 kg/ha, 80kg/ha for the direct seed drilling and 90kg/ha for pre-germinated seed broadcasting methods. For seedling transplanted rice, the rice was planted first in nursery and later thinned at three weeks old and transplanted within average of three seedlings per hill on prepared seed beds, at 20cm x 20cm within and between rows, just as in direct seed dibbling method, whilst that of direct seed drilling was 5cm x 20cm within and between rows. Direct seed dibbling, seed drilling and broadcasting of pre-germinated seeds were done on the same day seeds were sown in the nursery, to maintain the same seedling age for all treatments.

All plots had common standard cultural practices, and fertilizer dose of N.P.K. (15, 15, 15) in the form of nitrogen, phosphorus and potash was applied to the crop as basal NPK (60, 30, 30 kg/ha) and was later top-dressed with 30 kg/ha nitrogen in the form of sulphate of ammonia.

Recorded average climatic data within the 3-4 months growing period for 2010 were rainfall, 582 mm, temperature, 29.9^{o}C, relative humidity, 79%, sunshine, 8.6 hours and solar radiation, 20.2 MJ m^{-2} d^{-1} . Those of 2011 growing period were rainfall, 625 mm, temperature, 27.5^{o}C, relative humidity, 86%, sunshine, 7.2 hours and 18.9 MJ m^{-2} d^{-1}.

Data was recorded on percentage germination, established plants and number of tillers using averages of two quadrate (20 cm x 20 cm) throws at 8 weeks after planting, days to 50% flowering, number of panicles per square area at 100% booting; plant height at maturity, days to maturity. Plants at maturity were manually harvested within 10 m^2 area from base, bound, air dried, panicles separated from stalks, manually threshed, winnowed and recovered paddy weighed and recorded as paddy yield per hectare. The straw was then weighed and recorded as weight per square area.

Data collected from above parameters was subjected to analysis of variance and differences among treatments means were separated using Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1994).

RESULTS AND DISCUSSIONS

Growth and development and planting method

The two cropping seasons of 2010 and 2011 and their means indicated that there were significant effects (LSD 5%) of planting methods on IR12979-24-1 ("Digang") establishment. Though crop emergence and establishment are mostly influenced by variety traits (Rowland and Whiteman, 1993), the least mean established plants counts of 101 and 113 in 2010 and 2011; were respectively recorded in pre-germinated seed

broadcast plots. The two years seasons means followed the same trend as the individual years, with the highest means in direct seed dibbled plots (156 plants/m^2) and direct seed drilled plots (141 plants/m^2) which were significantly different from seedling transplanted plots (129 plants/m^2) and pre-germinated seed broadcast plots (107plants/m^2) (Table-1). This finding is in line with Oyewole, *et al*. (2010) that dibbling methods had the highest establishment of plants than the seed drilling methods; but not with seedling transplanting methods, probably due to variety traits differences in establishments under different conditions and locations.

Table-1. Effect of planting method on growth and development of "Digang" rice under upland condition (values are the means).

Parameters	**Germination** (%)			**Established plants/m^2**			**Days to 50% flowering**			**Plant height at maturity** (cm)			**Days to maturity**		
Planting method	**2010**	**2011**	**Years Mean**	**2010**	**2011**	**Years Mean**	**2010**	**2011**	**Years Mean**	**2010**	**2011**	**Years Mean**	**2010**	**2011**	**Years Mean**
Direct seed dibble	76	79	78	152	159	156	56	59	58	90.2	94.3	92.3	89.5	92.3	91.1
Pre-germinated seed broadcast	70	74	72	101	113	107	76	81	79	95.2	99.2	97.3	122.2	120.1	121.1
Direct seed drill	73	77	75	139	143	141	50	54	52	93.5	98.2	96.0	85.2	89.3	87.3
Seedling transplant	89	94	92	125	133	129	66	71	69	99.2	112	105.6	104.8	107.2	106
LSD (5%)	16.4	17.4	16.6	13.1	15.7	14.3	15.1	18.0	16.5	10.2	14.9	12.4	13.9	15.9	15.0

Generally, the emergence was low in pre-germinated seed broadcast and this could have arisen from inability of seeds to have perfect contact with the soil to facilitate water uptake, as reported by Chapman and Carter (1976) that seeds are often not properly buried in broadcast plots resulting in low germination and establishment counts. Rowland and Whiteman (1993) and Oyewole and Attah (2007) also indicated that, broadcasting generally depresses seed germination, and thereby affect crop establishment due to seed loses through pests and diseases and other environmental factors.

Though plant establishment has effect on its final height, the height of a crop to some extent determines its susceptibility to lodging above a certain height. Plant height was not significantly different (LSD 5%) in direct seed dibble, pre-germinated seed broadcast and direct seed drill methods, but was significantly different from seedling transplanted method, probably due to immediate and continuous rains after transplanting observed in both years. There were also differences between plant heights of both years which could have been due to variations in their climatic variables that have influence on crop growth and development.

Days to flowering was significantly (LSD 5%) influenced by different planting methods, as direct drilling and direct dibbling methods had shorter days than pre-germinated seed broadcasting and seedling transplanted methods (Table-1). The direct seed drilling method recorded early flowering and shorter maturity days because it had better crop establishment, with higher intra competition due to shorter spacing and plant density per unit area, triggering quicker reproductive phase responses. This was followed by direct dibbling, with about ten days shorter than seedling transplanting method, agreeing with IRRI (2008) study reports that depending on a cultivar, direct seeded rice matures seven to ten days earlier than transplanted rice.

The pre-germinated seed broadcast recorded highest average of 79 days to 50% flowering, which definitely affected and prolonged maturity period to 121 days within the two growing seasons. The longer days to flowering and maturity in seedling transplanting and pre-germinated seed broadcasting method, could be due to longer period required for crop establishments compared to other methods. As indicated by Dingkuhn, *et al*. (1991), the growth dynamics and partitioning patterns of rice depend on cultural practices, particularly on planting methods. Though "Digang" is quite early in maturity, the maturity period greatly depends on the crop genotype and cultural practices, and "Digang" growth and development responses to different planting methods should be considered when selecting the most appropriate planting method for its yield.

Yield and components of yield and planting methods

Varieties are commonly judged and selected based on yield and its attributed traits. There are however factors, be it direct or indirect that contribute to the yield of a crop. Results in Table-2 shows that planting methods can affect growing environment of a crop and subsequently influence its yield.

Table-2. Planting method on yield components and yield of "Digang" rice under upland conditions (values are the means).

Parameters	**Tiller count/m^2**			**Panicle count/m^2**			**Straw dry matter/m^2** (Kg)			**Paddy yield** (Tons/ha)		
Planting methods	**2010**	**2011**	**Years Mean**	**2010**	**2011**	**Years Mean**	**2010**	**2011**	**Years Mean**	**2010**	**2011**	**Years Mean**
Direct seed dibble	320	334	327	312	319	315	1.5	1.6	1.6	2.4	2.5	2.5
Pre-germinated seed broadcast	292	311	302	285	289	287	1.1	1.3	1.2	1.6	1.7	1.6
Direct seed drill	304	313	309	296	301	299	1.3	1.4	1.4	2.0	2.3	2.2
Seedling transplant	326	344	334	315	324	320	1.6	1.7	1.7	2.5	2.8	2.7
LSD (5%)	24.2	25.0	24.4	22.8	23.3	22.5	0.3	0.3	0.4	0.5	0.6	0.3

Yield though is a major trait through which a cultivar is selected, there are other component factors which directly or indirectly influence the potential of a cultivar in a given situation or condition. Apart from inherent potential of a crop, the environmental influence on this potential determines how it is manifested and optimized. For instance, the mean effects of increasing plant population by different planting methods, is increased competition between adjacent plants (Hay and Walker, 1989) which subsequently affect yield. This could be due to various physiological processes that affect leaf sheath and blade extension and overall development processes under varying planting methods and spacing. As a result of spacing and profuse tiller development in seedling transplanted rice, its low initial establishment effect on final tiller and panicle count differences was nullified, and subsequently out yield direct seed dibbling and seed drilling methods.

Though "Digang" can achieve maximum yield under relatively low plant densities, there were significant differences between planting methods on paddy yield, with the least being that of pre-germinated seed broadcast. This findings agrees with Kipps (1983) that, tendency exist in rice to tiller profusely in reduced plant population per unit of land area; and this could lead to non-significant differences between tiller formation on total dry matter and paddy yield per hectare between direct seed drilling, seed dibbling and seedling transplanted plots. It is also observed that, the direct seed drilling and pre-emergence seed broadcasting methods were not significantly different in most of the parameters examined. This finding is in line with Oyewole, *et al*. (2005) and Graham and Ellis (1980), that broadcasting gives cereal crops yields similar to drilling methods under the same agronomic conditions.

The tiller count was significantly (LSD 5%) affected by planting method in "Digang" rice. The average tiller number per square area for direct dibbling (327) and seedling broadcasting (334) were higher and significantly different from direct seed drilling (309) and pre-germinated seed broadcasting methods (302). The higher tiller count in direct seed dibble and seedling transplanted methods could have been due to optimal plant spacing. This agrees with IRRI (2008) that transplanting enables optimal spacing, and good spacing can increase tillers and paddy yield over poor spacing and/or other planting methods. Planting methods and growing environment are therefore among factors influencing yield of the crop. Proper spacing is said to ensure good water management (Mazid, *et al*., 2003) and photosynthetic activities and assimilate partitioning (Kundu, *et al*., 1993), thereby resulting in good yield in well spaced rice fields.

Greater number of panicles was observed in seedling transplanting method (320) followed by direct seed dibbling method (315), which were both not significantly different. The panicle count in direct seed dibbling and seedling transplanting methods were significantly different from pre-germinated seed broadcasting method, but not from direct seed drilling method. There is however more labour cost in rice transplanting, and under field conditions, less number of hills are likely to be planted per unit area (25-35 hill m^{-2}) which may result in reduced plant population (Subbaiah, *et al*., 2002; Gill, *et al*., 2008). This shows that, if time is spent on transplanting rice with adequate spacing, more plant stand, tillers and panicle per stand will result in higher yield.

Planting method had influence on "Digang" yield, as seedling transplanting method recorded significantly higher paddy yield (2.7 tons/ha) than direct dibbling and pre-germinated seedling broadcasting, but not with direct dibbling method (2.5 tons/ha). The observation of Anon (2004) is in line with this study finding that higher grain yields of rice was obtained from transplanting method than the grain yield obtained from direct seeding method. This finding also agrees with Dingkuhn, *et al*., (1991) that transplanted rice produce significantly higher grain yield than direct seeded. Though Garcia *et al*. (1995) indicated that direct seeded crops had better initial establishment and gave higher grain as compared to transplanted crops, their experiment was carried under lowland conditions which most often differ from that of upland.

Transplanting method recorded the highest average yield because the planting distance ensure air

circulation, water and light which are basic factors necessary for photosynthesis (Baloch *et al*., 2002). This is in agreement with reports by IRRI (1984) that transplanting enables optimal spacing, and proper spacing can increase tiller and paddy yield. The comparatively low paddy yields recorded especially in pre-germinated seed broadcasting methods than seedling transplanting method could have been due to exposure of seeds to pest destruction and weed competition in broadcast conditions. It could be some of these problems of rice broadcasting that Damkheong, *et al*., (1980) indicated, in areas where labour is found, transplanted rice will produce gross economic return than other methods under upland conditions; and even where labour is scarce and costly, transplanting through seedling throwing will give higher yield and income than other methods (Manjappa and Kataraki, 2002; Sanjitha Rani and Jayakiran, 2010).

In this study, direct dibble and seedling transplanted methods recorded higher and significant tiller count and paddy yield than other methods. This could be due to plant spacing in seedling transplanting and direct seed dibbling methods, resulting in limited competition as compared with direct seed drilling and pre-germinated seed broadcasting methods.

CONCLUSIONS

The paddy yield of "Digang" in the study suggests that, farmers using any of the planting methods investigated under upland condition may not be at disadvantaged as reduction in established plants per unit area may be compensated for by increase in tiller formation, panicle count and other yield components. However, "Digang" establishment and overall yield performance is low in pre-germinated seed broadcasting method, as the method does not bring seed in early perfect contact with the soil for adequate water uptake necessary for seed emergence and establishment. Though there have been reports of higher paddy yields resulting from better crop establishment of rice in seed drilled methods, drilling is an expensive technology in terms of its labour requirements. However, direct seed drilling method recorded relatively low values, and was also not significantly different from direct seed dibbling method, in most parameters examined. The straw dry matter, on which animals and other cultural needs depend, was higher in seedling transplanting and direct seed dibbling methods, and both were significantly different from pre-germinated seed broadcasting and direct seed drilling methods.

Generally, the seedling transplanting and direct seed dibbling methods gave the highest dry matter and paddy yields in 2010 and 2011 growing seasons, and were also not significantly different in almost all examined parameters. These two planting methods are among those often prevalent on farmers' fields, and could therefore be chosen for "Digang" rice cultivation under upland condition of Bawku, and similar savanna agro-ecologies.

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