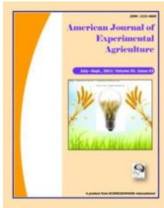

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Effects of Planting Dates on Leaf and Grain Yield of Black-Eyed Bean Cowpea Type in Mashonaland East Province in Zimbabwe

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Aims: To determine the effect of planting date on leaf and grain yield of Black-eyed bean (BEB) of cowpea type,
Study Design: A field experiment was carried out in a factorial arrangement in randomised complete block design with three replications.
Place and Duration of Study: The study was conducted at both on-station (University of Zimbabwe, Crop Sciences Department experimental blocks and on-farm in Mashonaland East Province, Mutoko District, Katsukunya village during the 2005 – 6 and 2006 - 7 cropping seasons.
Methodology: Two sowing dates (14 December and 16 January) were used. The leaf harvesting treatments were started four WACE for the cowpea to set a sufficient framework on both stations. Leaf harvesting was done every week on Fridays for on-station and Wednesdays for on-farms sites and terminated at the 50% flowering stage for BEB after harvesting for four weeks (7 WACE) at the UZ site and for three weeks (6 WACE) in Mutoko a total of twenty-four plants were harvested per each treatment.
Results: The results showed that planting date had significant effect on leaf, grain and biomass yield. Highest (1492 kg/ha) grain yield was obtained with late planting in January while highest

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(1225.5 kg/ha) leaf yield was obtained with early planting in December
Conclusion: Planting date is an important factor influencing both leaf and grain yield of cowpea.

Keywords: Planting date; black-eyed bean; yield; harvesting intensity and interval.

1. INTRODUCTION

Cowpea (*Vignau niguiculata* L. Walp) (Fabaceae) is a very important food legume in the world. It contains about 22% protein and constitutes a major source of protein for resource-poor rural and urban people [1]. Worldwide the crop is highly valued for its leaf and grain for human consumption and for forage and therefore often has a dual utility [2]. Black-eyed bean (BEB) was introduced into the country by non-governmental organisation to offer farmers an early maturing, highly nutritious cowpea type and relatively low input crop which has also had a market appeal. Planting and production practices are similar to the usually grown local landraces; however farmers had little knowledge on the effects of some of these practices on BEB.

The great importance of BEB crop is not only from its ability to grow in the new reclaimed areas as an economic crop, but also for producing high leaf and grain yield under the stressful conditions as compared to the local landraces. BEB is a as short season crop, and its growth period is almost half of the local landraces [3]. It is drought tolerant, making it suitable for the marginalized areas where most rural areas are situated.

It is known that high productivity of any crop is as a result of many factors and operations. Moreover, the quantity and quality of the crop is affected by the cultivation management practices prevailing in the agro ecological zone where the crop is grown, hence, the pronounced role of the agronomical processes such as planting dates, sowing density, soil fertility and rainfall requirements play very important role on the total performance of the crop [4].

Planting date of a crop is considered important among other factors that influence growth and productivity. It plays a vital role in germination, growth, yield and quality of the crop [5]. Therefore, edaphic factors vary under the Zimbabwean Natural Regions conditions. Also planting date is a great factor in organising and securing work schedule for farmers. Planting BEB on a suitable date according to environmental conditions of the region is therefore the best method to maximise yield and quality. There is therefore a great need to determine the responses of BEB that has been released to the smallholder farmers in Zimbabwe to different planting dates, hence the objectives of this study were:

- To determine the direct influence of planting dates on the performance of BEB cowpea type.
- To develop recommendations for BEB production practises under semi-arid conditions in Zimbabwe.

2. MATERIALS AND METHODS

2.1 Experimental Sites

The experiment was conducted across four sites, three sites in Mutoko, Nyadire area and the other site at the University of Zimbabwe, Department of Crop Science experimental plots.

2.1.1 University of Zimbabwe, department of crop science

The experiment was carried out at the University of Zimbabwe, Department of Crop Science in the 2005/6 and 2006/7 seasons. The Department of Crop Science is located in the suburb of Mount Pleasant, 10 km north of the city centre of Harare. University of Zimbabwe is in Natural Farming Region IIa and receives about 750 – 1000 mm rainfall per annum. The area lies at 1500 metres above sea level, latitude 17°31^1 east and longitude 30°50^1 south. The arable experimental plots are flat with slopes of 2% or less. The soils are red fersiallitic clay with more than 30% clay soil using the Zimbabwean classification system [6]. Fertility of these soils is maintained through regular application of inorganic fertilizers, crop rotations and good management.

2.1.2 Mutoko Nyadire area

This area is in Mashonaland East Province, the experiment was carried out in Mutoko District, Katsukunya village under Chief Kanyongo 15 km from Mutoko centre in 2005/6 and 2006/7 seasons. The area is situated at latitude 18º

10[1]east and longitude 032°17[1] south and its 812 meters above sea level. It is in Natural Region III which is characterized by miombo woodland with three marked seasons: a warm wet summer (November-April), a cool dry winter (May-August) and a short hot dry spring (September-October). Soils are mainly coarse-grained sands and sandy loams over sandy clay loams [7]. Rainfall is confined to summer, and is in the range 450 – 650 mm per annum. There are periodic seasonal droughts and severe dry spells during the rainy season hence drought tolerant crops are recommended. The area was chosen because it simulates conditions under which most small-holder farmers are located and also cowpea varieties do very well under the conditions in the area. The soils are derived from granite rock and are sandy, light textured and of fair agricultural potential. However, due to their structural and textural characteristics, the soils are subject to high levels of erosion and leaching under high rainfall conditions. Fertility of these soils is rapidly lost through poor management practices. The main climatic constraint to dryland crop production in Mutoko is rainfall. Temperatures also play an important role in the area high temperatures results in high potential evaporation rates leaving the soils dry [7].

2.2 Description of Varieties Used in the Experiment

2.2.1 Black-eyed bean (BEB)

BEB is a cowpea type with large white grain with a black patch around the hilum, hence the name. It has been recently introduced into the country by non-governmental organizations mainly due to its attractive colour that raises the market potential, as well as its high nutritional value that has potential to raise health levels in the smallholder farming sector. BEB is determinate and is well adapted and combines excellent stable yields with very good tolerance to drought. The variety is short seasoned, requiring less than 100 days to reach physiological maturity, needing about 70 – 75 days of warm weather to mature, hence allowing its production twice in any one rainy season or can be planted late in the season in higher rainfall areas [3].

2.2.2 Local landrace *(Chigwa)*

It is an indeterminate variety which has been grown by smallholder farmers for a long time which can be trailing, semi-trailing or twining. The tolerance of the crop to dry conditions and its ability to fix nitrogen makes it an ideal crop for smallholder farmers who farm in marginal areas, but its main drawback has been low grain yields. This landrace takes approximately five months to mature. Local landraces provide tender leaves for an extended period [8].

2.3 Soil Analysis

At each experimental site soil samples were taken on both on-farm and on-station sites for physical and chemical analysis at the Chemistry and Soils Research Institute of Zimbabwe (Table 1).

2.4 Planting Dates

The first season experiments were planted on the 14th of December 2005 for on-station and the on-farm was planted on the 15th of December 2005 and the second experiments were planted on the 16th of January 2006on the on-station and the 17th of January 2006for the on-farm. The second season experiments were planted on the 14th of December 2006 for on station and on the second experiments were planted on the 16th of January 2007 on the on-station and the 17th of January 2007 for the on-farm.

2.5 Experimental Design and Treatments

2.5.1 On-Station

The experiment was set up as 2 x 2 x 6 x 2 factorial, with planting dates as first planting (14 December and second planting (16 January), cowpea variety (BEB and *Chigwa*), leaf harvesting intensity (one leaf, two leaves and three leaves), and leaf harvesting frequency (weekly and bi-weekly) as factors. A control in which no leaf was harvested was included for each variety. Hence the experiment was made up of 12 treatment combinations.

Treatments were arranged as a randomized complete block design with three replications. The gross plot size was 2.7 m x 2.5 m consisting of 6 rows, 2.5 m long, spaced 0.45 m apart. The net plot size was 0.9 m x 1.90 m, consisting of two middle rows, 1.90 m long and a total of twenty-four (24) plants were sampled for both leaf and grain yield. A basal dressing of Single Super Phosphate (20.5%, P2O5, S 12.9%) was dribbled into open planting furrows at 40 kg ha^{-1}. Cowpea seeds were sown by hand. Two weeks after crop emergence (WACE) seedlings were

Table 1. Summary of soil analysis results for all the experimental sites in the 2005 – 6 and 2006 – 7 seasons respectively

	UZ sites		Mutoko sites		
	Block 9	**Block 13**	**Chinyanga**	**Chirimanzu**	**Munetsi**
Soil texture	MG/SC	MG/SCL	MG/S	MG/S	MG/S
Soilcolour	Dark Brown	Dark Brown	Pale Brown	Pale Brown	Light Brown
pH ($CaCl_2$)	5.9	5.6	4.9	4.6	4.7
Mineral Nitrogen (ppm)	37	35	3	9	11
Initial Nitrogen (ppm)	17	13	14	6	5
Phosphorus (ppm)	36	37	10	13	11
Potassium (ppm)	0.28	0.19	0.09	0.11	0.14
Calcium (ppm)	7.51	6.15	0.76	0.89	0.90
Magnesium (ppm)	2.69	2.87	0.38	0.35	0.34
Total Chromium (ppm)	9.8	8.3	1.4	1.5	1.2

MG- Medium-grained SCL- Sand clay loam SC - Sand Clay S – Sand

thinned to an in-row spacing of 15 cm to achieve the recommended plants/ha population.

2.5.2 On-farm

VECO organization provided the established links to the community and the intrinsic knowledge of farmers' concerns. This was done to improve the timeliness of sowing, trial supervision and contact with farmers. The selected farmers received free of charge cowpea seed; agro-chemicals for recommended practices and all the land preparations expenses. Agronomic details were the same as on-station. The treatment combinations were as follows:

1. no leaf harvested
2. 1 leaf harvested weekly
3. 1 leaf harvested 2 weekly interval
4. 2 leaves harvested weekly
5. 2 leaves harvested 2 weekly interval
6. 3 leaves harvested weekly (this was left out because there were no leaves,)

2.6 Establishment and Maintenance of Experiments

2.6.1 On-station experiment

On-station experments was planted on land from which a crop of maize had been grown as green mealies previously. After removal of stover, the existing weed growth was killed by application of Gramoxone (paraquat 25%, 75%. inert ingredients) applied at the rate of 189.39 litres/ha. The herbicide was applied using a knapsack sprayer calibrated to apply 200 litres of spray liquid ha^{-1}. After the scorching and collapse of weeds, three days after herbicide application, remaining green weeds were cleared by hand hoeing.

The second experiment was planted after a crop of green maize. A basal dressing of Single Super Phosphate (20.5% P_2O_5 S 12.9%) was dribbled into open planting furrows at 40 kg ha^{-1}. Two weeks after crop emergence (WACE) seedlings were thinned to an in-row spacing of 15 cm to achieve the recommended 150000 plants/ha population. To reduce snail damage in the first two WACE, broadcasting of snail and slug killer (metaldehyde 2.0%, carbaryl 2.0%, captan 0.5%, and inert ingredients) was done at two, three and four WACE at the rate of 8 kg ha^{-1}. Dimethoate (40% emulsifiable concentrate, 60% inert ingredients) was applied at 0.760 litres ha^{-1} on three occasions at four, six and seven WACE to control aphids. Plots were kept weed-free throughout the experiment by hand hoeing. On-station, BEB was attacked by *Ascocyta phaseolorum* during pod formation in the first growing season, and was controlled with alternating sprays of Benomyl (50% butylcarbomyol, 50% inert ingredients), copper oxychloride (85% Cu, 15% inert ingredients) and Dithane M45 (80% mancozeb, 20% inert ingredients).

2.6.2 On-farm experiments

Experiments were established by the researcher with participation of farmers who provided land, labour and made observations. Land preparation was done by farmers using ox-drawn mould board ploughs and harrowed to a fine tilth before planting furrows were opened using hoes. Planting and general management of the fields were as on-station.

2.6.3 Harvesting and measurements

The leaf harvesting treatments were started four WACE for the cowpea to set a sufficient framework on both stations. Leaf harvesting was done every week on Fridays for on-station and Wednesdays for on-farms sites and terminated at the 50% flowering stage for BEB after harvesting for four weeks (7 WACE) at the UZ site and for three weeks (6 WACE) in Mutoko a total of twenty-four plants were harvested per each treatment. Harvesting of the *Chigwa* continued for ten weeks (up to 14 WACE) at the UZ site and eight weeks (up to 12 WACE) at Mutoko sites; because of its indeterminate characteristics, *Chigwa* grows vegetatively for a longer duration than the BEB. Fresh weight of leaves was determined using a balance (Sartorius 1507 model) soon after harvesting. Leaf dry weight was determined by oven-drying leaves at 70% for 48 hours until there was no further weight loss, and then weighing the leaves.

Grain for the BEB was harvested at harvest maturity as indicated by the turning of pod colour from green to brown and rattling of grain in pods, at 14 WACE for on-station experiments and 12 WACE for on-farm experiments. Harvesting of the local landrace was done 17 WACE at both on-station and on-farm sites. Moisture content was determined using a digital moisture meter. Above-ground biomass was harvested on the same day as the pods.

2.7 Statistical Analysis

Collected data was subjected to analyses of variance (ANOVA) using GENSTAT (Version 6.0, 2005). Assumptions of ANOVA for normal data were carried out using GENSTAT (Version 6.0, 2005). Leaf and grain yield data across on-farm sites were subjected to homogeneity of variance using Bartlett's test using the formula (used when degrees of freedom are equal) outlined in Gomez and Gomez, [9]:

$$\frac{(2.3026)\,(f)\,(k \log s^2p - \sum_{i=1}^{k} \log si^2}{1 + [(k+1)/3kf]}$$

Where s^2 = error mean square
f = degree of freedom of each s^2
k = number of variances
log = logarithm base 10

3. RESULTS

3.1 Leaf Yield

3.1.1 Effects of planting dates, leaf harvesting intensity, leaf harvesting interval and variety on dry leaf yield

Planting dates had highly significant ($p<0.001$) effect on cowpea variety performance on leaf yield. Local landrace had the highest (1225.5kg/ha) leaf yield than BEB in all the seasons, on all the planting dates (Fig. 1). Leaf harvesting intensity was significantly ($p<0.001$) affected by planting dates at both on-station and on-farm sites for the 2005 – 6 and 2006 – 7 seasons (Fig. 1). Leaf harvesting interval had a significant ($p<0.001$) effect on the leaf yield on planting dates.

There was a significant interaction ($p<0.001$) in leaf harvesting intensity, leaf harvesting interval, cowpea variety and planting dates for all the seasons. The interaction is shown by the response of the cowpea varieties to the different planting dates, intensities and interval. For the planting dates, leaf yield decreased with late planting. However, for leaf harvesting intensity, leaf yield increased with increase in intensities. For leaf harvesting interval leaf yield increased with weekly harvests and was decreased for every fortnightly harvest, except for three leaves where it was done fortnightly only as there were no enough leaves for weekly harvests. Early planting dates produced the highest leaf yield for both varieties on all the sites for all the seasons (Fig. 1).

3.2 Grain Yield

3.2.1 Effects of planting dates, leaf harvesting intensity, leaf harvest interval and variety on grain yield

Grain yield responded significantly to planting dates, hence there was significant effect ($p<0.001$) of planting dates on grain yield on all the sites (Fig. 2). Cowpea variety had significant ($p<0.001$) difference grain yield on all the sites.

There was a significant ($p<0.001$) interaction in planting dates, leaf harvesting intensity, leaf harvesting interval and variety on grain yield on both sites as shown in the Fig. 2. The interaction is shown by the differential response of the two cowpea varieties on grain yield to planting dates,

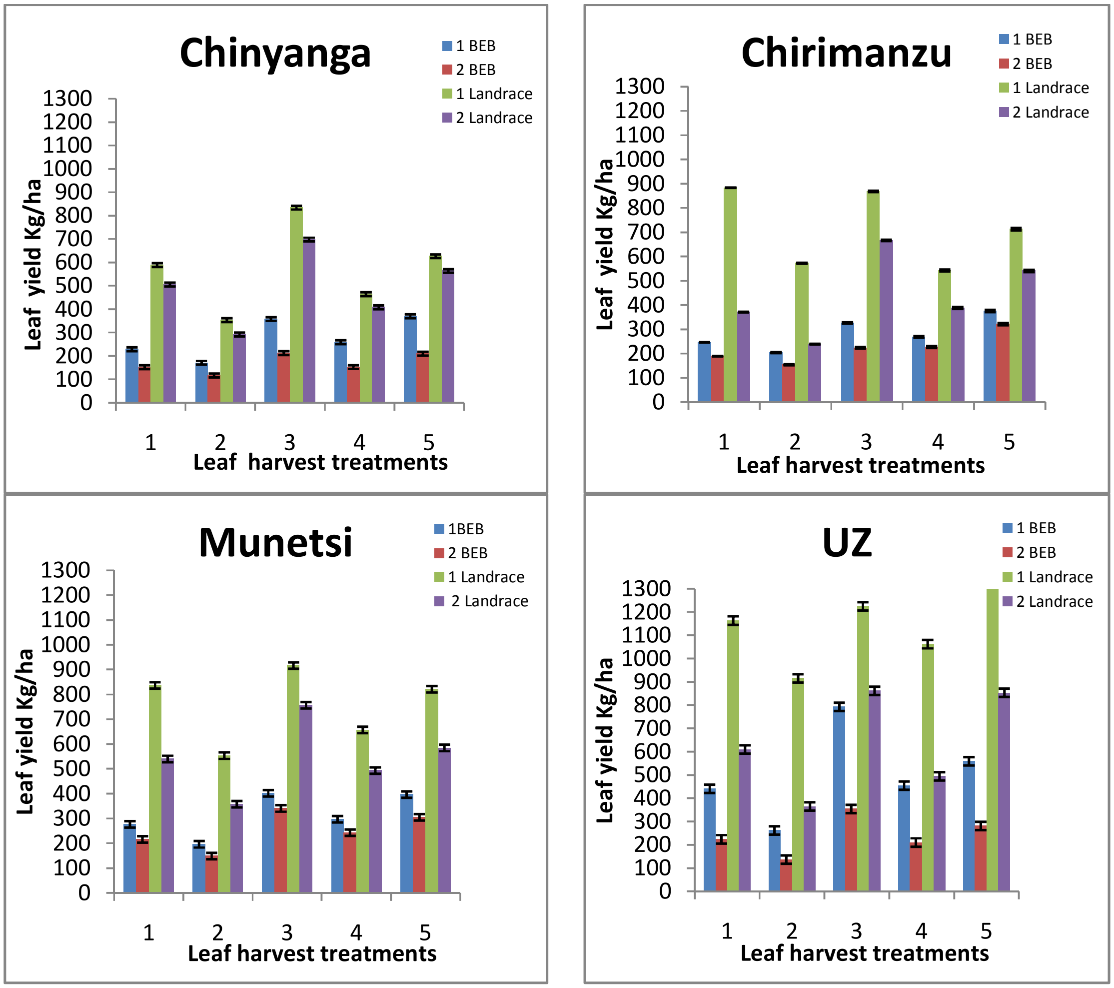

Fig. 1. Combined effects of planting dates on leaf yield of BEB and local landrace for both on-farm and on-station sites. Planting dates were 1BEB – 14 December, 2BEB – 16 January, 1Landrace – 15 December, 2Landrace – 17 January. Leaf harvesting treatments 1, 2, 3, 4 and 5 represents one leaf harvested weekly, one leaf harvested fortnightly, two leaves harvested weekly, two leaves harvested fortnightly, three leaves harvested fortnightly respectively.

leaf harvesting intensity and interval. Late planting dates in January produced the highest grain (1492kg/ha) yield than early planting dates in December (964kg/ha). BEB produced the highest grain yield in all the planting dates in all the leaf harvesting intensities and interval on all the sites in all the seasons. Harvesting two leaves produced the lowest grain yield in all the sites whereas the control and harvesting one leaf fortnightly produced the highest yield as there were significant differences on the two treatments. Leaf harvesting interval had highly significant ($p<0.001$) effect on grain yield. Harvesting weekly produced less grain than harvesting fortnightly (Fig. 3).

3.3 Aboveground Biomass

3.3.1 Effect of planting dates, leaf harvesting intensity, leaf intensity interval and variety on aboveground biomass

Similarly like leaf yield, planting dates had significant effect ($p<0.001$) effect on aboveground biomass yield hence, yield was significantly influenced by planting dates. Early planting in December resulted in more aboveground biomass than planting late in January. Cowpea variety responded significantly to aboveground biomass yield with the local landrace (17219 kg/ha) producing the highest biomass yield than BEB (9111 kg/ha) in both sites. Generally, the UZ site produced the highest aboveground biomass (Fig. 3).

4. DISCUSSION

The study revealed that planting dates influences cowpea grain yield. Hence, there is need to grow the crops on the best utilization of moisture, nutrients and solar radiation on an optimum planting date in order to obtain the recommended yields. Therefore, by choosing the best planting date determines the different stages of plant growth at which the plants can come in accordance with preferred environmental conditions that lead to increased photosynthesis output resulting in increased yield. In this study, leaf and aboveground biomass high yields obtained from the early or first planting date suggests that the growth conditions were optimum for the vegetative growth and conversely the low grain yields in this phase indicate that the conditions in the late or second planting dates could be sub-optimal. The vegetative growth tendency observed in this experiment implies that they are enabling growth conditions available, therefore the advantage of early planting lead to high biomass yield. In [10], authors Faukner and Mackie, showed that cowpeas planted early in the season in Southern

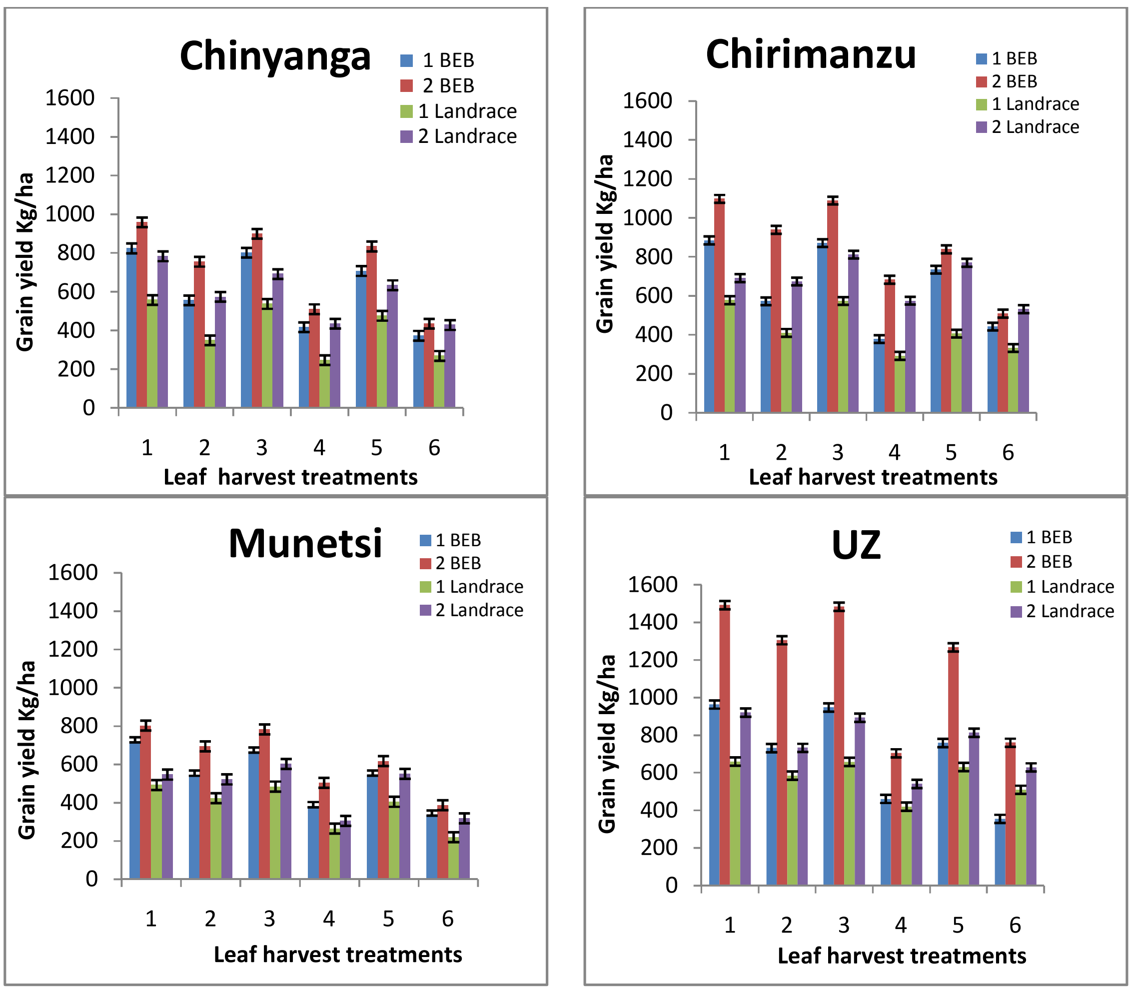

Fig. 2. Combined effects of planting dates on grain yield of BEB and local landrace for both on-farm and on-station sites. Planting dates were 1BEB – 14 December, 2BEB – 16 January, 1Landrace – 15 December, 2Landrace – 17 January. Leaf harvesting treatments 1, 2,3, 4, 5and 6 represents no leaf harvesting, one leaf harvested weekly, one leaf harvested fortnightly, two leaves harvested weekly, two leaves harvested fortnightly, three leaves harvested fortnightly respectively.

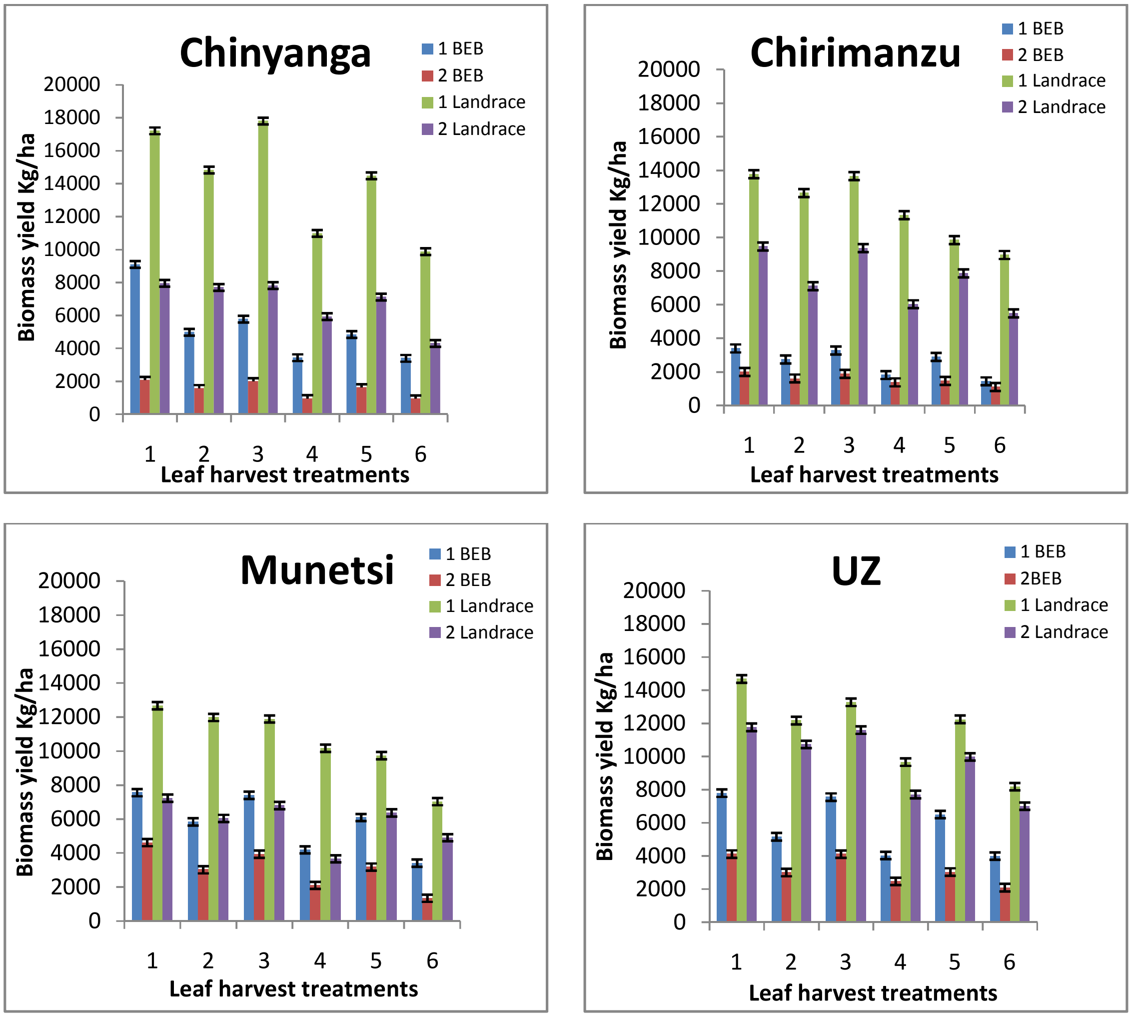

Fig. 3. Combined effects of planting dates on biomass yield of BEB and local landrace for both on-farm and on-station sites. Planting dates were 1BEB – 14 December, 2BEB – 16 January, 1Landrace – 15 December, 2Landrace – 17 January. Leaf harvesting treatments 1, 2,3, 4, 5and 6 represents no leaf harvesting, one leaf harvested weekly, one leaf harvested fortnightly, two leaves harvested weekly, two leaves harvested fortnightly, three leaves harvested fortnightly respectively.

Nigeria produced little or no seed due to the production of dense foliage at the expense of pod formation, then later on another researcher attributed the production of dense foliage to good soil and too much rainfall. It was also observed that weather conditions prevailing at any given time can be more conducive to the vegetative growth than pod formation [11]. The results are in agreement with [5] who also observed that there are numerous factors that contribute to the realization of a successful crop yield and one of them was planting date management which has a profound effect on the development and final outcome of the crop. However, in this study it was found that selection of a specific variety will have a large impact on the way in which planting date should be managed. As was observed in the experiment the selection of the local landrace was ideal as the early planting produced more leaf yield than late planting and this also occurred in the BEB crop. Hence, the time frame in which the crop can be planted due to weather and or other circumstances should have a large impact on the selection of a suitable variety [12]. Therefore, early plantings result in higher vegetative growth tendencies at the expense of the grain yield in both the local landrace and BEB. Previous reports also showed that in late planting situation, higher yields potentials are often realised from a more determinate, shorter season variety as it was observed from this study on BEB, whereas the indeterminate local landrace produced low grain yields with late planting as they were not able to mature the pods formed late in the season. For grain yield, the results of the study revealed that the late planting date offered better growing conditions due to temperatures coincidences of flowering and insemination flowers with more activity of insects and appropriate weather, more nutrients and photosynthetic materials are transmitted to the plants [13].

However, on leaf harvesting, the study revealed that leaf harvesting reduces cowpea grain yield. Whilst increasing leaf harvest intensity increased leaf yield significantly, this occurred at the expense of grain yield as the reduction of grain yield was presumably related to leaf harvest intensity. In this study, the more drastic reduction in grain yield could be explained by the fact that leaves are the major determinants of source strength, their harvesting will result in reduced source strength and subsequently lower yields by reducing the amount of photo-assimilates partitioned on the grain during grain fill and new vegetative growth. The effect of leaf harvesting on grain yield observed in this study also confirms the report by [14], which produced similar results where limited harvest of leaves had a detrimental effect on yield of cowpea harvested at maturity because of reduction in photo-assimilates.

In addition, leaf harvesting interval had also an effect on the yield performance of the cowpea where harvesting weekly resulted in more leaf yield but less grain yield. With longer harvest intervals specifically for one leaf harvested at fortnightly intervals for both the determinante (BEB) and the determinate (local landrace) the resultant leaf yield was less and did not affect the grain yield because of compensatory effect in terms of cowpea biomass. This also confirms the findings by [15], who revealed that removal of few leaves in cowpea resulted in proportionally little leaf area removal, hence the negligible negative effect in yield at moderate harvest intensities and extended intervals.

Regardless of planting dates, the results from this study also indicated that indeterminate types due to their vegetative characteristics tend to produce more leaves than determinant types. This was in agreement with earlier reports [16]. Determinant types have no time to recover from defoliation because they have a short flowering period whereas indeterminate types have a long flowering period, hence have enough time to recover from defoliation and channel photo-assimilates produced to pods resulting in higher grain yields.

5. CONCLUSION

In this study, it can be concluded that both BEB and the local landrace, although very well adapted to the region may not well be used for early planting dates as they faced a decline in grain yield. Hence, they can only be planted in January for quantity and quality enhancement. The results of this study also suggest that some varieties could be grown for grain harvest, while others could be grown for vegetable harvesting as the yield efficiency was suppressed by the combination of leaf and grain harvest.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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