Efficacy of *Parkia biglobosa* fruit powder on the control of *Striga* in cowpea cropping systems in the Sudan-Savanna, Nigeria

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**Abstract**

Field experiments were conducted at the Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano (Latitude 120 03’N and Longitude 80 32’E) and Jigawa State Research Institute Farm, Kazaure (Latitude 120 06’N and Longitude 8047 E) in 2015 rainy season. The study was aimed to evaluate the effects of *Parkia biglobosa* fruit powder in the control of *Striga* (*Striga gesnerioides* (Walp) Vatke), growth and yield of cowpea (*Vigna unguiculata* (L.) Walp) under field condition. The treatments consisted of three methods of *Parkia* fruit powder application (seed coating, basal and the control) and seven cowpea varieties (IT90K-277-2, IT97K-205-8, IT97K-390-2, IT97K-461-4, IT97K-568-11, IT98D-288, IT98K-131-2 and IT03K-378-4). These were laid in a split plot design and replicated three times. Methods of application of *Parkia* fruit powder were assigned to the main plot, while cowpea varieties were in the subplot. Results of the study showed that the control plots had the highest *Striga* count m⁻² in both locations. The variety IT90K-390-2 recorded the highest number of *Striga* m⁻².
(5.11) while 1T97K-205-8 had none. Among the varieties tested, IT90K-277-2 recorded the highest grain yield (1841.3 kg ha\(^{-1}\)) while IT03K-378-4 had the lowest grain yield (1439.4 kg ha\(^{-1}\)) at BUK. Coating cowpea seeds with Parkia fruit powder recorded lowest stand count on most varieties. Basal application of Parkia fruit powder to IT90K-277-2 recorded higher grain yield (2137 kg ha\(^{-1}\)) and lower Striga count m\(^{-2}\) (0.66), and is therefore recommended for Striga control.

Keyword: Agriculture

1. Introduction

Cowpea is one of the most important food legume crop in the semi-arid tropics. It is drought tolerant and warm weather crop well adapted to the drier regions of the tropics, where other crops do not perform well. Food and Agriculture Organization (FAO) reported that about 5.4 million tons of cowpea were produced annually with Africa producing nearly 5.2 million tons (FAO, 2017). Nigeria is the world largest cowpea producer and consumer of cowpea accounting for 61% of production in Africa and 58% worldwide (FAO, 2017). The relatively high protein content (23%) makes cowpea an important supplement to the diet of many African people (Bressani, 1985), who consume cereals, roots and tubers which are high in carbohydrates and low in protein. Cowpea haulm provides valuable animal feed during the dry season. An important feature of cowpea is that it fixes atmospheric nitrogen through symbiosis with nodule bacteria (Bradyrhizobium sp), thereby increasing N levels in the soil for the benefit of the following crop in rotation.

Striga is a genus of obligate hemi-parasite that infect roots of important crops such as cowpea, maize and sorghum. It is the most important biotic constrain to cowpea production which reduced cowpea yield by 73–100% (Aaron et al., 2013). Once Striga becomes established in a field, its eradication becomes very difficult. It was reported to reduce cowpea grain yield by 75–95% on susceptible cultivars in the field (Hayatu et al., 2016). This significant yield reduction results in little or no food for millions of subsistence farmers and consequently aggravates hunger and poverty (Lado et al., 2016). Several cultivable lands have been abandoned as a result of high Striga infestation, as such Striga undermine the struggle of people to attain food security and economic growth in the Sudan savanna agro-ecology of Nigeria.

The use of Parkia pulp has been found to improve the soils physicochemical properties and inhibits the germination of S. gesnerioides seeds in cowpea at Burkina Faso (Itta et al., 2014). They also reported that application of 2, 3 and 4 g hill\(^{-1}\) of Parkia pulp before planting significantly reduced population of crops infested with Striga and Striga shoot count while crop vigour was increased. Similarly, Magani et al. (2010) reported 29.1 and 38.8% less Striga hermonthica emergence.
in field and greenhouse respectively, when Parkia based products were used in maize.

*Striga* is very difficult to control as most of the control methods have proved ineffective. The intensive and repeated application of agrochemicals produces a wide range of side-effects that poses potential hazard to the environment (Meksawat and Pornprom 2010). Based on aforementioned, there is a need to look for efficient methods of *Striga* control with little or non-hazard to the environment. The use of naturally occurring plant products is one of such method with potentials of reducing the detrimental impacts of agro-chemicals and their harmful effects on human health and the environment. The use of Parkia pulp was reported to successfully control *Striga* in cowpea (Itta et al., 2014). There were however little or no documented report on the efficacy of Parkia fruit powder and the method of its application on the control of *Striga gesnerioides* in cowpea. If successful, the research result will be a breakthrough on the struggle to control the parasite. The study was therefore conceived with a view to harness the potentials of Parkia biglobosa fruit powder on *Striga* control and in enhancing cowpea productivity under field condition.

2. Materials and methods

The experiments were conducted at Teaching and Research Farm of Faculty of Agriculture, Bayero University Kano, BUK (Latitude 120 03’N, Longitude 80 32’E. and altitude 481 m above sea level) and Jigawa State Research Institute Farm, Kazaure (Latitude 120 06’N, Longitude 8047 E. and altitude 475 m above sea level) during 2015 rainy season. Treatments consisted of factorial combination of three methods of application of Parkia fruit powder (seed coating, basal application and the control) with seven cowpea (IT90K-277-2, IT97K-205-8, IT97K-390-2, IT97K-461-4, IT97K-568-11, IT98D-288, IT98K-131-2 and IT03K-378-4) varieties. These were laid in a split-plot design with three replications. Application method was assigned to the main plot while cowpea varieties were assigned to the sub-plot. The choice of the varieties was based on the results of preliminary trial in the screen house (results not shown). This was also based on their ability to germinate and grow despite application of Parkia fruit powder.

Mature and dried Parkia fruits were collected from the field at Bayero University, Kano Farm. The Parkia pods were opened to separate the fruit powder from the seeds. The powder was allowed to dry under shade and then grounded into a fine powder (<1 mm). Viable seeds of *Striga gesnerioides* were obtained from International Institute of Tropical Agriculture (IITA) Kano sub-station. Suspension of Parkia fruit powder was prepared by dissolving 40 kg ha\(^{-1}\) of Parkia fruit powder in 100 liters of water. This was coated to 25 kg of cowpea seeds and agitated thoroughly. The coated seeds were allowed to dry under shade before sowing. For the
basal method, the cowpea seeds were sown along with the Parkia fruit powder at the rate 40 kg ha\(^{-1}\). The control treatments were however sown without Parkia fruit powder.

The land was ploughed, harrowed and ridged at 0.75 m inter-row spacing. The gross and net plot sizes were 9 m\(^2\) and 4.5 m\(^2\) (as comprised of 4 and 2 ridges of 3 m length) respectively. The experimental field was heavily infested with 2000 Striga seeds stand\(^{-1}\) using the procedure described by IITA (1997). Clean and viable Striga seeds were mixed with sand of approximately the same proportion with Striga seeds to ensure uniform distribution of Striga seeds with the sand. Striga spoon of 0.94 g capacity was used to measure the amount of sand-Striga mixture hill\(^{-1}\) (IITA, 1997). Thus, 7615.9 g of Striga seeds and 50133.02 g of sand was used to infest 53,333 stands ha\(^{-1}\). A full Striga spoon (0.94 g) of Striga-sand mixture was sprinkle into each of the sowing hills and lightly covered with a thin layer of soils so as to cover the mixture while still leaving a depression that can be seen and planted onto at a later date.

Two treated cowpea seeds were manually sown in holes of about 4 cm deep at 20 × 75 spacing. Fertilizers were applied at the rate of 20 kg N ha\(^{-1}\), 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) and 20 kg K\(_2\)O ha\(^{-1}\) using NPK (15−15−15) and single Superphosphate (18% P\(_2\)O\(_5\)). Weeds other than Striga were controlled manually using hoe at 3 and 6 weeks after sowing (WAS). Insect pests were controlled using Cypermethrin 30 g \(\text{L}^{-1}\) plus dimethoate 25 g \(\text{L}^{-1}\) at 1 L ha\(^{-1}\) at two weeks interval using 20 litres knapsack sprayer. Harvesting was done by four successive handpicking of the mature dry pods from each net plot and the total was recorded.

Data were collected using 1 m\(^2\) quadrat on number of cowpea stands infected by Striga and Striga m\(^{-2}\). This was transformed using square root transformation. Cowpea stands were counted from net plot and extrapolated to per hectare basis at harvest. Crop dry matter plant\(^{-1}\) was determined at physiological maturity by uprooting three randomly selected plants from the sampling rows plot\(^{-1}\). These were oven dried at 750 to a constant weight and average recorded. Twenty pods from the net plots were randomly selected and their length measured using meter rule. These pods were manually threshed and the average number of grains per pod was recorded. The threshed grain from each net plot were weighed using electric weighing balance (CAMRY) and extrapolated to kilogram ha\(^{-1}\). Data collected were subjected to analysis of variance using SAS (SAS, V8, 2000) to evaluate the effects of the treatments. Significant treatment means were separated using Student New-man Keul (SNK).

3. Results

The effects of application methods of Parkia fruit powder and cowpea varieties on number of cowpea stands infected by Striga, number of Striga m\(^{-2}\), number of
cowpea stands ha\(^{-1}\) and crop dry matter from the two experimental locations are presented in Table 1. Results of the study indicated significant effect of application method of Parkia fruit powder on number of Striga infected cowpea stands, number of Striga m\(^{-2}\) and number of stands ha\(^{-1}\) from both locations. The control plots had the highest number of cowpea stands infected by Striga, number of Striga m\(^{-2}\) and cowpea stand count ha\(^{-1}\). Plots treated with basal application recorded the lowest number of Striga m\(^{-2}\) in both locations, which were also similar to the coated seeds. The crop dry matter was higher from the basal treatment only at Kazaure, which was also similar to the control but different from the seed coating method. The results further revealed that varieties had significant effect on number of cowpea stands infected by Striga and number of Striga m\(^{-2}\) at BUK, while that of Kazaure was not significant. IT97K-390-2 had the highest number of stand infected by Striga and number of Striga m\(^{-2}\). This was also at par with IT97K-277-2 but different from all other varieties. Similarly, IT97-205-8 had the highest number of cowpea stand ha\(^{-1}\). This was similar to IT97K-390-2 and IT98D-288 but different from all other varieties studied at both locations.

Basal application method recorded the highest crop dry matter plant\(^{-1}\) at Kazaure. This was similar to that of the control but different from seed coating method. Similarly, IT97K-390-2 recorded the highest number of Striga m\(^{-2}\) at BUK only. The result also showed that IT97K-205-8 recorded the highest stand count from both locations. This was also similar to IT97K-390-2, IT98K-131-2 and IT98D-288, but different from all other varieties. The crop dry matter plant\(^{-1}\) was also significant among the varieties at BUK. IT98D-288 gave the highest crop dry matter plant\(^{-1}\). This was also similar to all other varieties except IT97K-461-4 and IT03K-378-4 that had the lowest crop dry matter plant\(^{-1}\).

Table 2 shows the interactions of application methods of Parkia fruit powder and variety on number of cowpea stands infected with Striga, cowpea stands at harvest ha\(^{-1}\) and crop dry matter plant\(^{-1}\). Significant interaction of application methods and variety was observed on number of infected stands. This indicated that IT97K-461-4 from the control plots gave the highest number of Striga infested stands at BUK. All the varieties that were basally treated with Parkia fruit powder gave the lowest number of Striga infested stands except IT98K-131-2 from the basal and control treatments that was statistically different. The results also indicated significant interactions of application method and variety on number of Striga m\(^{-2}\) at BUK. This showed that IT97K-277-2, IT97K-390-2 and IT97K-568-11 from the control plots bears the highest number of Striga m\(^{-2}\). These were also different from all other varieties irrespective of application method that had the least number of Striga m\(^{-2}\).

The results of the investigation further revealed significant interactions of application method and variety on cowpea stand at harvest from Kazaure (Table 2). This was higher from IT97K-277-2 whose seeds were treated with Parkia fruit powder using
Table 1. Effects of *Parkia* fruit powder application method and variety on number of cowpea stands infected with *Striga*, number of *Striga* m\(^{-2}\), stand count ha\(^{-1}\) and crop dry matter plant\(^{-1}\) at BUK and Kazaure in 2015 rainy season.

| Treatments | BUK | KAZAURE |
|------------|-----|---------|
|            | Number of Cowpea Stands Infected by *Striga* | Number of *Striga* m\(^{-2}\) | Number of Cowpea Stand ha\(^{-1}\) | Crop Dry Matter Plant\(^{-1}\) (grm) | Number of cowpea Stands Infected by *Striga* | Number of *Striga* m\(^{-2}\) | Number of Cowpea Stand ha\(^{-1}\) | Crop Dry Matter Plant\(^{-1}\) (grm) |
| **Methods of Application (M)** | | | | | | | | |
| Seed coating | 0.33b | 0.41b (1.82b) | 14444c | 61.37 | 0.00b | 1.25a (1.73b) | 5611b | 7.50b |
| Basal | 0.29b | 0.33b (1.89b) | 26205b | 126.87 | 0.13b | 0.23b (1.78b) | 34251a | 24.02a |
| Control | 2.37a | 4.08a (2.41a) | 33801a | 75.60 | 0.91a | 5.15a (1.98a) | 36759a | 23.62a |
| Level of probability | 0.0191 | 0.0003 (0.0004) | 0.0195 | 0.1026 | 0.0058 | 0.0470 (0.0136) | 0.0019 | 0.0018 |
| SE+ | 0.337 | 0.201 (0.084) | 3779.11 | 16.723 | 0.100 | 3.021 (0.041) | 1442.5 | 1.405 |
| **Varieties (V)** | | | | | | | | |
| IT90K-277-2 | 1.88ab | 3.44ab (2.43ab) | 29259abc | 100.43ab | 0.44 | 13.22 (1.81) | 31481bc | 19.07 |
| IT97K-205-8 | 0.00b | 0.00b (1.73c) | 34335a | 78.57ab | 0.00 | 0.00 (1.76) | 39136a | 17.96 |
| IT97K-390-2 | 3.22a | 5.11a (2.73a) | 31988ab | 127.30a | 0.77 | 1.22 (1.96) | 35923ab | 24.25 |
| IT97K-461-4 | 0.33b | 0.33b (1.73c) | 19383c | 60.19b | 0.11 | 0.11 (1.76) | 21111d | 17.59 |
| IT97K-568-11 | 1.55b | 2.77ab (2.26bc) | 22099bc | 73.45ab | 0.62 | 0.87 (1.89) | 26111cd | 16.66 |
| IT98D-288 | 0.22b | 0.44b (1.81c) | 13827abc | 128.54a | 0.55 | 0.55 (1.86) | 33704ab | 20.00 |
| IT98K-131-2 | 0.55b | 0.66b (1.88c) | 20864bc | 84.26ab | 0.22 | 0.44 (1.84) | 23086d | 10.55 |
| IT03K-378-4 | 0.22b | 0.22b (1.76c) | 16780c | 50.83b | 0.11 | 0.11 (1.76) | 14198e | 20.18 |
| Level of probability | 0.0001 | 0.0002 (0.0001) | 0.0008 | 0.0004 | 0.1621 | 0.4314 (0.2698) | 0.0001 | 0.0719 |
| SE+ | 0.467 | 0.831 (0.128) | 2978.46 | 13.079 | 0.217 | 4.473 (0.063) | 1947.6 | 2.683 |
| **Interaction** | M x V | | | | | | | |
| | 0.0139 | 0.0063 (0.0019) | 0.8556 | 0.2631 | 0.4487 | 0.4754 (0.7724) | 0.0016 | 0.0014 |

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Student- Newman Keuls Test. BUK = Bayero University Kano, ( ) = transformed means.
Table 2. Interactions of methods of application of *Parkia* fruit powder and cowpea varieties on number of *Striga* infected cowpea stands, *Striga* m\(^{-2}\), cowpea stands ha\(^{-1}\) and crop dry matter at BUK and Kazaure in 2015 rainy season.

| Variety       | Method of application of *Parkia* fruit powder | Striga infected stand (BUK) | Number of *Striga* m\(^{-2}\) (BUK) | Stand count at harvest (Kazaure) | Crop dry matter (grm) Kazaure |
|---------------|-----------------------------------------------|-----------------------------|-------------------------------------|----------------------------------|---------------------------------|
|               | Basal                                         | Control                     | Coating                             | Basal                           | Control                        | Coating                        | Basal                           | Control                        | Coating                        |
|               | Basal                                         | Control                     | Coating                             | Basal                           | Control                        | Coating                        | Basal                           | Control                        | Coating                        |
| IT90K-277-2   | 0.66f                                         | 3.66e                       | 1.33f                               | 0.66b                           | 8.33a                          | 1.33b                          | 39629ab                         | 10055cd                        | 49.55c-f                       |
| IT97K-205-8   | 0.00f                                         | 0.00f                       | 0.00f                               | 0.00b                           | 0.00b                          | 0.00b                          | 42592ab                         | 10040gh                        | 52.55cde                       |
| IT97K-390-2   | 1.33f                                         | 7.33d                       | 1.00f                               | 1.66b                           | 12.00a                         | 1.66b                          | 44074ab                         | 10048ef                        | 38.10gh                        |
| IT97K-461-4   | 0.00f                                         | 51.00a                      | 0.00f                               | 0.00b                           | 1.00b                          | 0.00b                          | 28518bcd                        | 10035h                         | 44.44fg                        |
| IT97K-568-11  | 0.33f                                         | 4.33e                       | 0.33f                               | 0.33b                           | 8.00a                          | 0.00b                          | 31111bc                         | 10056cd                        | 56.33cd                        |
| IT98K-288     | 0.00f                                         | 0.33f                       | 0.33f                               | 0.00b                           | 0.66b                          | 0.33b                          | 42592ab                         | 10062b                         | 49.10def                       |
| IT98K-131-2   | 17.33c                                        | 32.33b                      | 0.00f                               | 0.00b                           | 2.00b                          | 0.00b                          | 28518bcd                        | 10041gh                        | 56.76c                         |
| IT03K-378-4   | 0.00f                                         | 0.66f                       | 0.00f                               | 0.00b                           | 0.66b                          | 0.00b                          | 15925cde                        | 10045fg                         | 38.31gh                        |
| SE±           | 0.810                                         | 0.440                       | 3.373                               |                                  |                                |                                |                                  |                                |                                |

Means followed by the same letter (s) in a column are not significantly different at 5% level of probability using Student-Newman Keuls Test. BUK = Bayero University, Kano.
basal application. This was also similar with IT97K-205-8, IT97K-390-2 and IT98K-288 from basal application but different from all other varieties irrespective of the application method. The crop dry matter plant$^{-1}$ was also influenced by the interactions of application method and variety at Kazaure only. Highest crop dry matter plant$^{-1}$ was observed from IT98K-288 from the control plots. This was also at par with all other varieties from the basal application method and the control, but different from IT97K-568-11, IT98K-288, IT98K-131-2 and IT03K-378-4 whose seeds were coated with Parkia fruit powder suspension and thus bears the lowest crop dry matter plant$^{-1}$.

Methods of application of Parkia fruit powder and cowpea variety had significant effect on pod length, number of grains pod$^{-1}$ and grain yield at both locations (Table 3). The results showed that basal application had the longest pods, higher number of grains pod$^{-1}$ and grain yield only at BUK. At Kazaure however, basal application and control had the longest pods and number of grains pod$^{-1}$. The basal method

### Table 3. Effects of application methods of Parkia fruit powder and variety on pod length, number of grains pod$^{-1}$ and grain yield at BUK and Kazaure in 2015 rainy season.

| Treatments                      | BUK                    | KAZAURE                 |
|---------------------------------|------------------------|-------------------------|
|                                 | Pod length (cm) | Grains pod$^{-1}$ | Grain yield (kg ha$^{-1}$) | Pod length (cm) | Grains pod$^{-1}$ | Grain yield (kg ha$^{-1}$) |
| Methods of Application (M)      |                       |                        |                            |                  |                        |                            |
| Seed coating                    | 7.69c                  | 5.24c                  | 1343.06c                   | 3.47b            | 0.97b                  | 1018.26b                   |
| Basal                           | 15.04a                 | 10.49a                 | 1908.40a                   | 10.34a           | 4.53a                  | 1189.70a                   |
| Control                         | 12.45b                 | 7.42b                  | 1701.75b                   | 10.57a           | 4.23a                  | 1037.87b                   |
| Level of probability            | 0.0066                 | 0.008                  | 0.0078                     | 0.0049           | 0.0049                 | 0.0199                     |
| SE$^+$                          | 0.784                  | 0.319                  | 162.855                    | 0.781            | 0.342                  | 22.128                     |
| Variety (V)                     |                       |                        |                            |                  |                        |                            |
| IT90K-277-2                     | 14.02a                 | 9.09abc                | 1841.3a                    | 10.30a           | 4.93a                  | 1149.05                    |
| IT97K-205-8                     | 13.91a                 | 10.15ab                | 1701.2ab                   | 10.58a           | 4.71a                  | 1145.80                    |
| IT97K-390-2                     | 14.91a                 | 11.62a                 | 1710.2ab                   | 7.85ab           | 1.36bc                 | 1113.60                    |
| IT97K-461-4                     | 12.71ab                | 7.94bc                 | 1593.4ab                   | 9.22ab           | 3.55ab                 | 1131.60                    |
| IT97K-568-11                    | 9.83bcd                | 6.42cd                 | 1620.1ab                   | 7.66ab           | 3.95a                  | 1140.24                    |
| IT98D-288                       | 9.10cd                 | 4.65d                  | 1635.2ab                   | 3.56b            | 0.84c                  | 1173.53                    |
| IT98K-131-2                     | 11.56abc               | 7.37bcd                | 1667.6ab                   | 8.84ab           | 4.94a                  | 1169.46                    |
| IT03K-378-4                     | 7.77d                  | 4.44d                  | 1439.4b                    | 6.68ab           | 1.65bc                 | 1133.52                    |
| Level of probability            | 0.0001                 | 0.0001                 | 0.0695                     | 0.0362           | 0.0001                 | 0.4567                     |
| SE$^+$                          | 0.884                  | 0.826                  | 179.77                     | 1.447            | 0.650                  | 120.064                    |
| Interaction M x V               | 0.0001                 | 0.0001                 | 0.0202                     | 0.1593           | 0.1228                 | 0.4567                     |

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Student- Newman Keuls Test. BUK = Bayero University Kano.
also recorded the highest grain yield in this location. The results also showed that, IT97K-390-2 from BUK produced the longest pods and higher number of grains pod\(^{-1}\). These were similar to IT90K-277-2 and IT97K-205-8 but higher than all other varieties. The results also indicated that IT98K-131-2, IT97K-568-11, IT97K-461-4, IT97K-205-8 and IT90K-277-2 recorded the highest number grains pod\(^{-1}\) than all other varieties. Significant effect of variety on grain yield was observed at BUK only. IT97K-277-2 had the highest grain yield. This was not statistically different from all other varieties except IT03K-378-4 that produced the lowest grain yield.

The interactions of application of Parkia fruit powder and cowpea varieties on pod length, number of grains pod\(^{-1}\) and grain yield were significant at BUK only (Table 4). This indicated that all the varieties recorded similar pod length when Parkia powder was applied basally. These were also at par with the control treatment. The varieties IT97K-568-11 and IT03K-378-4 whose seeds were coated with Parkia fruit powder suspension bears the shortest pods than all the other varieties tested in this experiment. Consequently, IT97K-390-2 coated with Parkia fruit powder recorded the highest number of grains pod\(^{-1}\), while IT97K-568-11, IT98K-288, IT03K-378-4 whose seeds were coated with Parkia fruit powder suspension gave the lowest number of grains per pod. The results of the interaction further revealed that basal treatment with Parkia fruit powder on IT97K-277-2 produced the highest grain yield; which was also at par with IT03K-378-4, IT97K-568-11, IT98K-288 and IT98K-131-2 that were treated with basal application but different from IT97K-568-11 and IT03K-378-4 whose seeds were coated, thus bearing the lowest grain yields.

4. Discussion

Low Striga infestation was observed when Parkia fruit powder was applied using basal method. This suggests that the method can be used to control Striga infestation in cowpea. It implies that Parkia fruit powder may have phyto-toxic effect on Striga growth and development leading to significant reduction of number of Striga m\(^{-2}\). This may also deplete the Striga seed bank, thereby ensuring efficient control of Striga over time. Similar observation was reported by Ibrahim et al. (2011) that maize seeds soaked for 20 minutes in Parkia based products suspension resulted in significantly fewer number of maize plants infected with Striga as compared to those soaked in distilled water. Similarly, Itta et al. (2014) reported that application of Parkia products significantly delayed flowering of Striga and reduced number of capsules per Striga. Coating of cowpea seed with Parkia fruit powder reduced stand count in cowpea which resulted in lower number of emerged Striga. Seed coating might damage cowpea seed and cause poor germination and hence unsuitable for use in controlling Striga on cowpea.
Table 4. Interactions of methods of application of Parkia fruit powder and cowpea varieties on pod length, number of grains pod$^{-1}$ and grain yield at BUK in 2015 rainy season.

| Variety          | Method of application of Parkia fruit powder | Pod length (cm) | Number of grains pod$^{-1}$ | Grain yield (kg ha$^{-1}$) |
|------------------|---------------------------------------------|-----------------|-----------------------------|---------------------------|
| IT90K-277-2      | Basal Control                             | 16.60a          | 12.46a                       | 7.08bcd                   |
|                  | Coating                                    | 14.00a          | 10.96a                       | 10.31bc                   |
|                  | Control                                    | 14.00a          | 9.71bc                       | 9.71bc                    |
|                  | Coating                                    | 14.00a          | 9.71bc                       | 9.71bc                    |
| IT97K-205-8      | Basal Control                             | 14.10a          | 13.96a                       | 1714.66abc               |
|                  | Coating                                    | 13.66a          | 13.56a                       | 1747.40abc               |
|                  | Control                                    | 13.66a          | 13.56a                       | 1747.40abc               |
|                  | Coating                                    | 13.66a          | 13.56a                       | 1747.40abc               |
| IT97K-390-2      | Basal Control                             | 15.10a          | 13.56a                       | 1875.45abc               |
|                  | Coating                                    | 16.06a          | 16.06a                       | 1565.33a-d               |
|                  | Control                                    | 16.06a          | 16.06a                       | 1565.33a-d               |
|                  | Coating                                    | 16.06a          | 16.06a                       | 1565.33a-d               |
| IT97K-461-4      | Basal Control                             | 15.66a          | 13.43a                       | 1772.14abc               |
|                  | Coating                                    | 8.93ab          | 8.93ab                       | 8.93ab                    |
|                  | Control                                    | 8.93ab          | 8.93ab                       | 8.93ab                    |
|                  | Coating                                    | 8.93ab          | 8.93ab                       | 8.93ab                    |
| IT97K-568-11     | Basal Control                             | 16.73a          | 12.76a                       | 1993.14ab                |
|                  | Coating                                    | 2.00c           | 2.00c                        | 2.00c                     |
|                  | Control                                    | 2.00c           | 2.00c                        | 2.00c                     |
|                  | Coating                                    | 2.00c           | 2.00c                        | 2.00c                     |
| IT98K-131-2      | Basal Control                             | 15.76a          | 14.13a                       | 2030.62ab                |
|                  | Coating                                    | 4.90bc          | 4.90bc                       | 4.90bc                    |
|                  | Control                                    | 4.90bc          | 4.90bc                       | 4.90bc                    |
|                  | Coating                                    | 4.90bc          | 4.90bc                       | 4.90bc                    |
| IT03K-378-4      | Basal Control                             | 13.73a          | 9.60ab                       | 788.81ab                 |
|                  | Coating                                    | 3.96bc          | 3.96bc                       | 3.96bc                    |
|                  | Control                                    | 3.96bc          | 3.96bc                       | 3.96bc                    |
|                  | Coating                                    | 3.96bc          | 3.96bc                       | 3.96bc                    |

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Student-Newman Keuls Test.
The control plots had the highest number of stand at harvest, indicating that *Parkia* fruit powder has phyto-toxic effect on the test crop. Soaking the seed in *Parkia* fruit powder suspension affects emergence of cowpea, suggesting that the method is unsuitable for some cowpea varieties. This corroborates with the work of *Lado et al.* (2016) who reported that soaking cowpea seeds in Imazaquin reduced cowpea emergence. Basal application of *Parkia* fruit powder gave the highest crop dry matter, longer pods, higher number of grains pod\(^{-1}\) and grain yield. This indicated that seed vigour was not affected by the phyto-toxic effect of *Parkia* fruit powder and hence the method can be used to control *Striga*. Basal application of *Parkia* fruit powder control *Striga* efficiently, resulting to accelerated cowpea growth due to lack of competition. This is in agreement with the findings of *Ibrahim et al.* (2011) who reported inhibitory effects of allelo-chemicals present in the *Parkia* fruit powder extract on maize.

The significant effects of seed coating and control treatments in decreasing pod length, number of grains per pod and grain yield observed in this study suggests the basal treatment of cowpea with *Parkia* fruit powder to be the best and hence suitable for enhanced cowpea production. The poor performance of seed coating and control on yield and yield characters might also be attributed to the effect of seed treatment with *Parkia* on number of stand. The effective *Striga* control by the *Parkia* fruit powder observed in this study might have been the reason for higher grain yield and yield characters. This is because higher number of *Striga* in the control plots, reduces the productivity of cowpea as reported by *Hayatu et al.* (2016) who noted negative effects of *Striga* on growth and yield character of cowpea.

The significant effect of variety on number of cowpea stands infected by *Striga* stand and number *Striga* m\(^{-2}\) in this study is a reflection of the differences in terms of *Striga* tolerance among these varieties. *Sawadogo et al.* (2010) reported similar observation on several cowpea varieties that are either susceptible or resistance to *Striga*. IT97K-205-8 did not support the emergence of *Striga* suggesting that it is resistant to *Striga* and hence can be used in *Striga* infested fields. The ability of the varieties, IT97K-205-8, IT97K-390-2 and IT98D-288 to bear the highest stand count than all other varieties could be due to their tolerance to the phyto-toxic effects of the *Parkia*. Similarly, the tendency of IT98D-288 in having the highest crop dry matter could be attributed to its higher number of leaves and branches which are all contributing factors to dry matter as reported by *Addo-Quoya et al.* (2011).

The tendency of the control treatment to bear the highest number of *Striga* infected cowpea stands and *Striga* m\(^{-2}\) than those treated with *Parkia* fruit powder is an indication of the effectiveness of *Parkia* fruit powder in controlling *Striga*. Thus *Parkia* fruit powder may have a depressive effect on the attachment and growth of *Striga* on cowpea. This is in agreement with the findings of *Magani et al.* (2010) and *Itta et al.* (2014), who reported significant reduction in the number of stands infested with...
Striga hermonthica and Striga gesnerioides when Parkia products were used on maize and cowpea in Burkina Faso and Nigeria, respectively.

Seed coating with Parkia fruit powder had absolutely inhibited emergence of IT95K-568-11, IT98D-288, IT98K-131-2 and IT03K-378-4. This suggests that seed coating with Parkia fruit powder negatively affects the germination of these varieties. It implies that the method is not suitable for these varieties and could not be recommended to the farmers. Treating IT97K-205-8 with basal method had higher number of stands indicating high level of resistance of this variety to the Parkia fruit powder. This method also increased pod length of IT90K-277-2, IT97K-568-11 and IT98K-131-2 at BUK. This may be attributed to the fact that these varieties are tolerant to the Parkia which effectively control Striga thereby making more photosynthates available to bear more pods. It could also be due to the corresponding effect of this application method on growth characters. Number of grain pod⁻¹ of most varieties treated basally were higher than seed coating and control. Similarly, treating IT90K-277-2 with basal method recorded higher grain yield than all other treatment combinations. This implied that the variety can be used to enhance cowpea productivity and control Striga. This finding however contradicts with that of Itta et al. (2014) who reported that Parkia pulp had no effect on pod weight and grain yield of cowpea.

5. Conclusion

The findings from this study make several contributions to the current literature. First, it provides evidence that, Parkia fruit powder reduced the number of S. gesnerioides in cowpea. This implies that there will be depletion of Striga seed bank in future, thereby ensuring control of Striga over time. It also shows that response of cowpea to Striga infestation was variety dependant, with some being more susceptible and or tolerant than others. Farmers can therefore adopt the use of basal method of Parkia fruit powder application in combination with other Striga management practices, such as tolerant varieties and also cultural practices. Further research is suggested to investigate the mechanism by which Parkia fruit powder control Striga.

Declarations

Author contribution statement

Abdulrahman Lado: Conceived and designed the experiments; Wrote the paper.
Fatima Umar Sani: Performed the experiments.
Shehu Usman Yahaya: Analyzed and interpreted the data.
Abubakar Kwalle Karaye: Contributed reagents, materials, analysis tools or data.
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The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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