RESPONSE OF CORN WEED: *Rottboellia cochinchinensis* LOUR CLAYTON, SEED TO WATER IMBIBITIONS AND VARYING POPULATION DENSITY

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Abstract

Weed is a limiting factor to crop production and thus, the attainment of food security in Africa where hunger is a constant threat. Though the concept of categorizing weeds and crops involve more of a human psychology than any botanical principle, from the point of view of agricultural production and food security, it is imperative that weeds or plants out of place deserve a control rather than co-existence. Control options are more constrained when plants are non-native with more of an invasive nature and complex biological adaptations, such as demonstrated by corn weed. Series of experiments were therefore conducted with the view to investigating all limiting factors to corn-weed germination as means to its control. Trials were conducted at Faculty of Agriculture, University of Ilorin, Ilorin, Kwara State, Nigeria. Old corn weed seeds used in these experiments were collected two years before the commencement of the experiment from fallow popcorn field in Bellah, Asa Local Government area of Kwara State, Nigeria and were stored at ambient temperature, while fresh corn weed seeds were collected when required from abandoned farm lands at the permanent site of the University. The sowing medium, dark perforated plastic buckets were filled with sterilized soils collected from fallow farmlands to within 2.5-cm of the brim to allow for watering, and the plants were liberally fertilized (NPK 15:15:15). Old corn weed seed stored for 2 years under ambient temperature recorded 9.32 per cent less weight than fresh corn weed seed at the commencement of the trial. Soaking old corn weed seed in water for 1hr led to 17.05 per cent weight gain as against 16.46 per cent in fresh corn weed seed. By the second hour of seed soaking, weight gain in fresh corn weed seed had drastically reduced to 1.57 per cent as against 16.77 per cent in old (stored) seed. While it took fresh corn weed 4 hours to attain maximum water imbibition, old (stored) corn weed seed attained maximum weight in 5 hours; gaining a total of 31.74 per cent weight, as against 22.50 per cent weight gain in fresh corn weed seed. Although, plant population did not significantly ($p \geq 0.05$) influenced time to commencement of tiller in corn weed, tiller number decreased with increase in plant population density. Corn weed produces large amount of seeds, which germinate sporadically in the field. These seeds are instrumental to the weed's rapid environmental colonization. Thus, an understanding of the seed process is vital in the control of corn weed.

Keywords: *Rottboellia cochinchinensis*, old and fresh seed, weight gain, and tiller formation.

Introduction

Within the challenges of crop production lie dominant role of weed pest in preventing the attainment of food security, particularly in Nigeria (Oyewole and Ibikunle, 2010). Weed interference can be a great challenge to crop production, with devastating effects. Besides direct effects in the form of competition with crops for space, nutrients and solar radiation, there are the indirect effects such as cost implication for weed control, and loss of school hours for family members involved in weed control, particularly where manual weeding is the common practice (Oyewole and Ibikunle, 2010). Oyewole and Ibikunle (2010) had observed that to surmount the problem of food insecurity in Africa, and Nigeria in particularly, Africa must address, besides other obstacles, the problems associated with weed interference particularly, obnoxious weeds, such as corn weed: *Rottboellia cochinchinensis*. They, however, stressed that weed control mechanisms should embrace better understanding of weed biology as tool in weed control. This is particularly so in the face of the persistence call for reduced herbicide use. Although commonly referred to as corn weed, *Rottboellia cochinchinensis* infestation is not

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limited to corn plant. Studies have shown that the weed is associated with other crops: sugar cane (Millhollon, 1965); pigeon pea (Sharma and Zelaya, 1986); soy bean (Pleasant *et al*., 1990); yam (Akobundu *et al*., 1981), among others.

Itchgrass as *Rottboellia cochinchinensis* is also commonly called is an erect strongly tufted, C4, annual grass, characterized as a vigorous competitor and for being able to reach a height of up to 4 m (Holm *et al*., 1977). Its common names in English Language and other languages relate to the silicaceous, fragile, irritating hairs covering the leaf sheaths that break off on contact with the skin. It is native to the Old World (Afro-Asian) and probably was introduced to the New World at the beginning of the twentieth century. Here, in its exotic range, infestations are considered to be the most severe, perhaps because of several contributing factors, including improved climatic compatibility, human intervention in disseminating the grass, favourable agronomic practices, and the absence of co-evolved natural enemies (Ellison and Evans, 1992, Valverde, 2004). In addition to Neotropical areas, where it is an important weed in several crops including maize, sugar cane, upland and rain-fed rice, beans, sorghum and some perennials, such as citrus and oil palm at early growth stages, it has been reported as a weed of many crops in several countries (Holm *et al*., 1977). Itchgrass is reported as a weed mostly from latitude 23°N to 23°S, within the 20°C isotherm (Valverde, 2004) but is also has the ability to grow, flower and set seed under some of the temperate regimes found in the United States where it can reach 75 - 100 per cent of its growth potential (Patterson *et al*., 1979, Valverde, 2004). Just in Central America and the Caribbean it is estimated that itchgrass affects more than 3.5 million hectares (FAO, 1992). It is also considered an important weed is West Africa (Chikoye *et al*., 2000).

Itchgrass infestations can result in up to 80 per cent crop loss or even abandonment of agricultural lands (Holm *et al*., 1977, Valverde, 2004). Poor resource farmers in tropical areas devote substantial amounts of time and inputs to control itchgrass in subsistence crops (Valverde, 2004). Farmers in the seasonally dry areas of the Pacific region in Costa Rica, for example, use an estimated 34 per cent of total inputs solely on itchgrass control, which is mainly done by a combination of manual (slashing) and chemical methods, particularly the application of paraquat (Calvo *et al*., 1996, Valverde, 2004). Control costs in maize might represent up to 26 per cent of the income obtained from selling the grain (Valverde *et al*., 1999a; Valverde *et al*., 1999b). Where present, farmers usually regard itchgrass as a troublesome weed. In Costa Rica farmers acknowledge its rapid growth and yield-reducing effects as the most detrimental characteristics of itchgrass and recognize the large amount of seed it produces (Calvo *et al*., 1996; Valverde *et al*., 1999b).

In slash-and-burn agriculture in South America, itchgrass invades fields cleared from forest and, especially, from fallow. Under such conditions farmers consider it one of the most undesirable weeds (Fujisaka *et al*., 2000, Valverde, 2004). In more input-intensive crops, such as sugarcane, itchgrass is a major weed and has been widely reported in several countries including Brazil (Arevalo and Bertoncini, 1994, Valverde, 2004), Costa Rica (Vargas-Acosta, 1993), Cuba (Maldonado, 2000), Guatemala (Jiménez *et al*., 1990), Malaysia (Anwar 2001), Mexico (Valverde *et al*., 2001), Trinidad (Bridgemohan and Brathwaite, 1989) and Venezuela (Valle *et al*., 2000, Valverde, 2004).

In view of the danger posed by corn weed, and the difficulties encountered in its control, coupled with the call for reduced herbicide use, as a result of the attendant environmental negative consequences, disruption, secondary pest outbreaks, pesticide resistance, gross wildlife and public health effect (Gutierrez, 1987), this research focused on understanding the various factors (seed placement, depth of seeding, de-husking of seed, seed wounding, soaking in de-ionized water and in fresh seed extracts) (Oyewole and Ibikunle, 2010), water imbibitions in corn weed seed, response of tiller to population effect, among others, which may limit seed germination, emergent, establishment, growth and development with a view to controlling the weed; as understanding the weed is an essential step in its control (Oyewole and Ibikunle, 2010).

Materials and Methods

All trials were conducted at the Faculty of Agriculture, University of Ilorin, Ilorin, Kwara State, Nigeria. Ilorin (Longitude 4.57^0 E, Latitude 8.53^0 N, dip 4.1^0 S), southwestern Nigeria, capital of Kwara State is a commercial, manufacturing, and transportation center situated in an agricultural region producing corn, sorghum, rice, cassava, yams, peanuts and livestock (Microsoft Encata Premium, 2009). Series of pot experiments were conducted with the view to investigating the limiting factors to corn-weed germination, growth and development as means to its control. Old corn weed seeds used in these experiments were collected two years prior to the commencement of the experiments, from fallow popcorn field in Bellah, Asa Local Government area of Kwara State, Nigeria and stored at ambient temperature in poly bags. Fresh corn weed seeds were collected when required from abandoned farm lands at the permanent site of the University. The sowing medium, dark perforated plastic buckets were filled with heat sterilized soils collected from advanced fallow farmlands to within 2.5 cm of the brim to allow for watering, and the plants were liberally fertilized (NPK 15:15:15) where required.

Experiment 1
Water imbibition in seed of corn weed:
Water uptake is vital to seed germination; the ability of seed to take up water will impact on its ability to germinate. Water activates hormones and enzymes, finally embryonic growth and development in a conducive, environment of temperature and other requirements. Batches of 50 seeds each of fresh and old corn weed were weighed into separate clean beakers containing 20 ml of distilled water. Water imbibitions, was determined as a measure of weight gained. To determine water imbibitions capacity, these batches of 50 seeds were removed every hour, wiped dry and weighed. This continued until constant weight was attained.

Experiment 2
Effect of plant density on tiller formation:
Ten plant populations were investigated (1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 plants per stand) under 40 per cent shade density, achieved in a pavilion. Treatment was replicated three times in a Complete Randomized Design (CRD). Compound fertilizer, NPK 15:15:15 was liberally applied at seed sowing. Number of tillers per plant was recorded every five days from the commencement of tiller formation until the 65th day after seed sowing.

Figure 1: Corn weed seed

Results and Discussion
Water absorption capacity of corn weed seed:
Water uptake is an important step towards the initiation of biochemical changes that lead to germination completion (Duran and Retamal, 1989; Wyatt, 1977; Powell., 1989; Kantar *et al*., 1996; Bewley, 1997). Old corn weed seed stored for 2 years under ambient temperature recorded 9.32 per cent less weight than fresh corn weed seed at the commencement of the soaking trial (Table 1). Soaking old corn weed seed in water for 1hr led to 17.05 per cent weight gain as against 16.46 per cent in fresh corn weed seed. By the second hour of seed soaking, weight gain in fresh corn weed seed had drastically reduced to 1.57 per cent as against 16.77 per cent in old (stored) seed. While it took fresh corn weed 4 hours to attain maximum water imbibition, old (stored) corn weed seed attained maximum weight in 5 hours; gaining a total of 31.74 per cent weight, as against 22.50 per cent weight gain in fresh corn weed seed. That stored corn weed seed recorded 9.32 per cent less weight than fresh corn weed seed was probably as a result of moisture loss in storage (Oyewole, 1992). This created greater hunger for water uptake in old seed in comparison to fresh seed. The short period of time it took both fresh and old corn weed seed to reach maximum weight probably accounted for its early germination capability as reported by Oyewole and Ibikunle (2010). However, rapid uptake can cause imbibition damages to the embryos of germinating seeds, particularly those that imbibe water quickly. Researchers had earlier observed that germination commenced with water uptake by imbibition and that under favourable conditions, rapid expansion and growth of the embryo cumulate in rupture of the covering layers and emergence of the radical.

Table 1: Mean variation in seed weight over time due to water absorption

Length of soaking (hrs)	Weight gained (gm)			
	Old seed		Fresh seed	
	Relative weight gained	Percentage weight gained	Relative weight gained	Percentage weight gained
0	0.0428	-	0.0472	-
1	0.0516	17.05	0.0565	16.46
2	0.0620	16.77	0.0574	1.57
3	0.0625	0.80	0.0601	4.49
4	0.0626	0.16	0.0609	1.31
5	0.0627	0.16	0.0609	0.00
6	0.0627	0.00	0.0609	0.00

Generally, corn weed produces large amount of seeds, which is reported to germinate sporadically in the field due to dormancy. Exogenous dormancy, which is caused by conditions outside the embryo occurs when seeds are impermeable to water or the exchange of gases. The experiment above, however shows that when in direct contact with water, both old and fresh seeds attain maximum water imbibitions within 5 hours, an indication that seed coat was not a limiting factor to water uptake in corn weed seed. The implication of this is that other factor(s) inherent in the seed coat must be responsible for the dormancy in corn weed seed (see Oyewole and Ibikunle, 2010), rather than the impermeable action of the seed coat. Seed coat may exert germination - restrictive action by being impermeable to water and oxygen or by its mechanical resistance to radicle protrusion; a property which have been positively correlated with seed coat colour due to phenolic compounds in diverse species (Debeaujon *et al*., 2000).

The observed response of old corn weed seed to water uptake is in line with previous research observations, where it was observed that uptake of water by a mature dry seed is triphasic, with a rapid initial uptake (phase I, imbibition) followed by a plateau phase (phase II, metabolic preparation for germination). Phase III is a further increase in water uptake which occurs directly after germination is completed. Phase-III water uptake causes hydraulic growth of the embryo and the emerged seedling. It was stressed that the plant hormone ABA inhibits phase III-water uptake (Gerhard, 2000). Gerhard (2000) reported that germination of tobacco follows a distinct pattern of events: rupture of the testa is followed by rupture of the endosperm. ABA (abscisic acid) specifically inhibits endosperm rupture and phase III water uptake, but does not alter the spatial and temporal pattern of phase I and II water uptake. The researcher pointed out that testa rupture was associated with an increase in water uptake due to initial embryo elongation, which was not inhibited by ABA. Over-expression of ß-1,3-glucanase in the seed covering layers of transgenic tobacco seeds did not alter the moisture sorption isotherms or the spatial pattern of water uptake during imbibition, but partially reverts the ABA inhibition of phase-III water uptake and of endosperm rupture. The researcher further stressed that dry seeds usually have water potentials between -350 and -50 MPa. Pointing out that this huge difference between the dry seed tissue water potential and the ambient water potential (in the case of pure water) results in rapid water influx during imbibition (phase I). He explained that water always flows from the higher to the lower water potential and the net flux will stop if the difference in water potential becomes zero (phase II). This leads to initial radicle extension due to reversible ("elastic") growth driven by osmotic water uptake (Gerhard, 2000). Further embryo growth, he explained, at and after the completion of seed germination requires cell wall loosening to allow phase III water uptake. The growth potential of the embryo and the constraining force of the endosperm and testa layers determine the completion of germination. Ambient water potential and temperature are of utmost importance for germination timing. Imbibition at reduced ambient water potential lowers seed water content, extends the lenght of phase II ("activation phase"), and delays/blocks entry into phase III. Radicle emergence and growth require critical (minimum) seed water content. Below this, germination is blocked (Gerhard, 2000). The hydrotime model (Gerhard, 2000) describes the dependence of germination on the water availability. At constant temperature the germination time can be calculated from the amount of water potential (in MPa) exceeding a base or threshold water potential (in MPa). Hydrotime (in MPa-days) is often a constant value for all seeds of a population, but the base water potential varies among individual seeds in a normally distributed manner. Hydrotime is the accumulation of MPa in excess of a base or threshold water potential, multiplied by the elapsed time to germination.

Table 2: Effect of plant density on tiller formation in corn weed seeds

Days after sowing	Population per stand										
	1	2	3	4	5	6	7	8	9	10	LSD
15	1.67	1.00	0.67	1.58	1.53	1.45	0.09	1.08	1.41	1.33	0.021
20	3.33	2.17	2.00	5.42	3.40	3.87	3.33	2.96	3.15	3.47	0.211
25	6.00	3.50	3.44	6.75	4.93	5.17	4.14	3.70	3.74	4.13	0.432
30	9.00	6.50	4.67	6.92	6.60	5.56	4.76	4.17	5.30	5.00	0.785
35	13.00	10.00	6.00	7.25	7.80	6.60	4.76	4.17	5.48	5.00	0.324
40	17.00	13.33	8.00	8.25	8.60	6.67	5.50	6.00	5.48	5.63	0.874
45	20.00	16.83	10.00	10.50	10.00	7.50	6.50	6.50	5.60	5.73	0.975
50	22.00	18.33	11.67	11.33	10.00	7.50	6.86	6.79	6.26	6.00	1.098
55	22.00	19.50	11.67	11.33	11.00	8.67	8.00	7.67	6.67	6.00	0.765
60	22.00	19.50	12.00	11.67	11.00	8.67	8.33	7.67	7.00	6.33	1.021
65	22.00	19.50	12.00	11.67	11.20	8.67	8.33	7.67	7.00	6.33	1.023

Effect of plant density on tiller formation in corn weed seeds

Stand population density did not significantly ($p \leq 0.05$) influence time to commencement of tiller formation in corn weed (Table 2). At 15 DAS (days after sowing), all populations investigated have commenced tiller formation. However, after a time, tiller number significantly decreased with increase in plant population density, such that, at the termination of the trial, the highest number of tillers was in one plant per stand (22 tillers), which progressively decreased with increase in plant stands. The response of tiller formation to plant population is in line with previous observations (Oyewole *et al*., 2005; Oyewole and Magaji, 2006; Oyewole *et al*., 2010) who reported less tiller formation with increase in plant population among wheat, millet and rice, respectively. These, observed that in crops that have the ability to tiller, there is the tendency for tiller to decrease with increase in plant population per unit area of land.

Conclusion

Itchgrass reproduces solely by seeds that are disseminated by water, farm machinery, and birds. Over long distances the main form of dissemination has been as a crop seed contaminant. Successful management of itchgrass depends on the depletion of its soil seed bank and preventing production of seed. No single control tactic is able to achieve this goal, thus a truly integrated strategy has been advocated to decrease itchgrass populations steadily. Available and promising tactics include mechanical, cultural, chemical and biological options. The ability or inability of a parent plant stock is inherent in the seed. Thus the seed is a vital means for propagating such parent stock. As seed, both in quality and quantity, is vital to the production of any parent weed stock, so is it also vital in the control of any weed. Corn weed produces large amount of seeds, which germinate sporadically in the field. These seed are instrumental to the weed's rapid environmental colonization. Thus an understanding of the seed process is vital in the control of corn weed.

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