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CLIMATE CHANGE WORSENS THE IMPACT OF *VACHELLIA NILOTICA* INVASION ON SAVANNA IN BALURAN NATIONAL PARK

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ABSTRACT

CLIMATE CHANGE WORSENS THE IMPACT OF *VACHELIA NILOTICA* INVASION ON SAVANNA IN BALURAN NATIONAL PARK

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Baluran National Park (BNP) savanna is the largest savanna in Java, a biodiversity conservation areas characterized by a domination of savannas housing indigenous herbivores mainly banteng (*Bos javanicus* d'Alton), the flagship of BNP. Unfortunately the population of banteng, the very endogenous flagship has been decreasing and is classified as" endangered". The savannas are invaded by invasive alien plant species mainly a small tree species, *Vachellia nilotica* (L P.J. Hurter & Mabb.), originated from India, altering those savannas into shrubs dominated by *V. nilotica* the invading tree species. The tree invasion shaded out grasses, which was dominant in the park such as *Dichantium caricosum* (L.) A. Camus a type of grasses preferred by the dwelling herbivores. The solution to these problems are not enough only to kill to reduce the population of *V.nilotica* but also to control those broadleaved weeds and the more importance of all is growing selected productive, nutritive, local grasses to ensure an adequate supply banteng and other herbivores. This research activities aims measuring the competitive ability of grasses and studying their competition against other vegetation in the greenhouse following the approach of replacement series. Selections of C_4 productive competitive grasses for establishing to develop productive pasture to support the livelihood of "banteng" and other fauna in the park. The prospective grasses and some weeds are collected from Savanna Bekol, BNP and grown in the green house and field site of SEAMEO BIOTROP, Bogor. The measurement of photosynthesis were carried out at different light intensity , 50, 100, 200, 400, 800 and 1600 µmol/m2/s using the Photosynthetic Gas Exchange Analyser LICOR LI-6400 at IPB University. A greenhouse experiment was also organized to study the competition ability between grasses of *Dichantium caricosum* and *Vernonia cymosa* by replacement series method. There are 9 grasses and 1 species of broad leaves weeds collected at Baluran National Park. *Dichantium caricosum* is a grass recommended to be cultivated at Baluran National Park due to the high survival rate during the dry season which has C_4 photosynthetic type. *V. cymosa* has a high competition rate than *D. caricosum*. *V. cymosa* has to be control to save the growth of *D. caricosum.* Good pasture of Baluran National Park dominated by *D. caricosum* will save the herbivores especially banteng and deers in grazing their feeds.

Keywords: *Dichantium caricosum, Vernonia cymosa, Baluran National Park, Invasive Alien Plant Species*

1. INTRODUCTION

1.1 Background

Baluran National Park (BNP) is a biodiversity conservation areas characterized by a domination of savannas housing indigenous herbivores mainly banteng (*Bos javanicus* d'Alton), the flagship of BNP. BNP has been recognized by IUCN as a "Word Heritage", while it is an outstanding recognition, it carries a responsibility to conserve this world heritage, for everybody in the world to enjoy this world wonder. Unfortunately, the population of banteng, the very endogenous flagship has been decreasing and is classified as" endangered". The government through the Directorate General of Natural Resources and Ecosystems as has been instructed by the ministerial decree No.58/ Menhut-II/2011 to elevate banteng population, established temporary fenced paddock to carry out a captive breeding program to increase the current banteng population at least 5% by 2020. It was not successful It should become a big drive to work hard to rehabilitate BNP as a whole.

The savannas are invaded by invasive alien plant species mainly a small tree species, *Vachellia nilotica*, originated from India, altering those savannas into shrubs dominated by *V.nilotica* the invading tree species. The tree invasion shaded out grasses, which was dominant in the park such as *Dichantium caricosum* (*aristatum?*), a type of grasses preferred by the dwelling herbivores. The invasion of *V. nilocica* has been degrading the savannas considerably reducing herbivores' feed driving the population of banteng into an endangered level. The climate change in term of increasing atmospheric [CO_2] impacted further not only shading out grasses, but also facilitated the growth of broadleaved weeds, such as *Bidens biternata, Eleutherantera ruderalis, Vernonia cymose, Thespesia lampas,* and others, which further competed grasses out, under the shade of *V. nilotica*. endangering further the livelihood of those herbivores. The problems of this national park while it has been sparked by the invasion of *V.nilotica*, it has been multiplied into multiple problems that must be overcome to prevent the degradation of biological diversity in the park, which are threatening the extinction of banteng. The process of invasion of *V. nilotika* on savanna has been progressing for the last 50 years, the damages are so severe that some location no more grasses growing underneath *V. nilotica*. The solution to these problems are not enough only to kill to reduce the population of *V.nilotica* including its seed bank under the soil, but also to control those broadleaved weeds and the more importance of all is growing selected productive, nutritive, local grasses to ensure an adequate supply banteng and other herbivores' feed by establishing selected productive nutritive local, grasses in the framework of rehabilitation of the park.

1.2 Objectives

The objectives of this research proposal are to design the best practices of savanna rehabilitation. There are at least 9 main components, i.e.

1. Eradication of broadleaved weeds and young small *V. nilotica* during early wet season, taking the advantage that the growth states of those broadleaved are still small (30-50 cm height) by foliar spray of selective herbicide (anyone of triclopyr, 2,4-D, fluroxypir),
2. Eradication of young *V. nilotica* and other woody weeds with the diameter of <5 cm. The eradication can be carried out by basal treatment using triclopyr at 1.5 l/120 L of diesel oil.
3. Eradication of *A.nilotica* seeds source in the form of mature *V. nilotica* plants, by mechanical cutting (chain saw) tree at less than 10 cm above the ground, during the dry season and followed by immediately brushing of 10% triclopyr dissolved in diesel oil on the cut stump.
4. Cut *A,nilotica* timber are given to the villagers, after deducted from their labour coat and shall be shall be brought out of the park.
5. Collection of C4 grasses, such as *Dichanthium caricosum, Brachiaria reptans, Sorghum nitidum, Schlerachne punctata, Themeda triandra* seeds, and planted in the green house for measuring their photosynthetic rate to ensure it is C4 plant.
6. Measuring the competitive ability of grasses and further studying their competition against other vegetation in the green house following the approach of replacement series.
7. Selection of C4 productive competitive grasses and their establishment to develop productive pasture to support the livelihood of fauna in the park.
8. Planting of selected local C4 grasses, following recommendations from the output of these research activities.
9. Establishment of selected grasses in a bigger paddock; constructed to accommodate the increasing population of captive breeding in the park. The established paddock (with selected grasses, shall be fenced and at leat divided into 2 sections, one for grazing and another one is left to recover from previous grazing.

The restoration program requires fund, times, consistent activities, with well tested component program and each component is carried out with optimum output. In BNP the technical components 1,2, 3 and 4 have been initiated although additional activities are required and organized if those programs will be integrated in its implementation in the field.

Such as the participation of local villages under the management of the local government (bupati), in the execution of activities. The expected social participation is that villagers are organized to cut the *V.nilotica* tree, and allowed to take the *V. nilotica* timber for themselves, probably with calculation betwwen the price of timber and the labour cost of cutting the *V. nilotica* tree.

The component 5, 6 and 7 are constituting the main objective of this research proposal.

1. Through laboratory works C4 grasses are to be collected
2. Their competitive capacities will be studied and standardized
3. To find a practicalways to ensure the domination of this selected grass in the framework of management of savanna to maintenance the biodiversity.

1.3 Expected Outputs

With the discovery of productive grasses, it will constitute the additional component of best management practices to manage the invasive *V. nilotica* and path ways to support the increase of banteng population recovering the biodiversity of the park. The growth of grasses producing seeds also support the life of other fauna living in the park especially many birds, such as peacock (*Pavo muticus)* and jungle fowl. It will also attract more visitors to enjoy the beauty of the savanna with grazing animals especially banteng, deer, and peacock and others to live up as a world heritage

2. STATE ART OF THE RESEARCH

2.1. Baluran National Park

In 1930, K.W. Dammerman, director of Bogor Botanical Garden, proposed that Baluran should become a protected forest. On 25 September 1937 the Governor General of the Dutch East Indies established Baluran as a Wildlife Preservation Area. It was re-established as such by the Minister of Agriculture and Land Affairs on 11 May 1962. On 6 March 1980, on the occasion of the World Strategic Conservation Day, it was declared a National Park by the Minister of Agriculture and then strengthened by a decree of the Ministry of Forestry no 279/Kpts VI/ 1997 dated 24th May 1997 stating that the area was 25.000 ha in the district of Situbondo, East Java province (TNB,2010). This park covers ecosystems extending from mountain to coastal ecosystems, with a greater portion in the form of savanna, and the home of various wildlife including banteng *(Bos javanicus* d'Alton*)*

(Gardner et al. 2016), kerbau *(Bubalus bubalis)*, rusa timor *(Cervus timorensis)*, kijang *(Munticus muntjak)*, anjing ajak *(Cuon alpinus)* (Kamler et al, 2015) , macan tutul *(Panthera pardus)*(Stein et al. 2016) burung merak *(Pavo muticus)* (Bird Life International,2018 a) jungle fowl, and hornbill (Bird Life International 2018b) . This savanna system is the only savanna in Java island and a very important conservation area mainly for banteng.

Baluran National Park, located in between 7^0 29' 10" and 7^0 55' 55" S and 114^0 29' 20" and 114^0 39'10" E, is characterized by the Baluran mountain having a summit at 1,247 m asl, raggedly divided into unequal portions by a huge caldera presumably from an ancient eruption (BNP, 2010). From this elevation, the mountain slopes down abruptly first, forming big steep gullies, after this, the slope is less steep but still forming rugged hills and valleys toward the coast of Madura Strait in the north, and the coast of Bali Strait in the east. In the northwest side, the slope is somewhat flatter but exhibited rough and rocky areas. In this side BNP borders with human settlement mainly Sumberanyar village. From this point down to the southern part the area is utilized for successful teak plantation and also borders with another human settlement mainly Wonorejo village, with natural boundaries in the form of river Bajulmati and river Klokoran. When seen from the satellite imagery the system looks like a piece of pancake attaches to the foothill of Ijen mountain (Fig.1).

Figure 1. The summit of Baluran Mountain generates the ecosystems of Baluran savana; the mountain forms a conspicuous land mass, that looks like a cake overlaying on top of Ijen mountain foothill, running directly to the sea of Madura straight at the northern side and Bali straight on the eastern side. Road connecting Situbondo and Banyuwangi runs on the western and southern sides of the land mass. (picture by Setiabudi, S.Hut. 2012).

BNP is under strong monsoon climate, and categorized as type E under Schmidt and Ferguson classification, dry climate with marked differences between dry and wet season. The temperature ranges from 27.2 – 30.9 ^{0}C, RH 77%, with wind speed 7 knot. Rainfall varies between 900 – 1600 mm with average 9 dry months annually. Rainy season is between November- April with highest rainfall usually recorded during December- January, while dry season is between April- October. The monsoon climate operating in BNP is delivering rainfall in southern portion of the mountain only enough to support the growth of monsoon forest up along the mountain and lower areas some of which is utilized for teak forest plantation. Having passed over Baluran Mountain the air goes down as a mass of dry air toward the sea giving little rain in its path capable of supporting the growth of savanna only, extending from Karang tekok from northern side, eastward coast surrounding Baluran Mountain.

BNP covers a very diverse ecosystem, from the summit of Baluran mountain down to the coastal areas with various ecosystems in between and from the point of view of banteng (*Bos javanicus*) as the flagship of the park those ecosystems may be integrated into one supporting the survival of banteng. The coastal sea ecosystem provides the needed salt for example, so in its daily activities this area constitutes an important portion of its home range. There are at least 6 types of ecosystems, i.e. (1). beach forest, (2). mangrove, (3). Estuary forest, (4). Savanna (2 types of savanna), (5). Monsoon forest (upper and lower elevation),

2.2. Savanna

Savannas are the largest portion of the ecosystems under BNP after monsoon forests, and has been speculated around 10.000 ha (Mutaqin, 2002); its existence of whic is the consequent of low water availability (annual rainfall 900 – 1.600 mm) and speculated also as a fire climax. There are two types of savanna,i.e. flat and undulating savanna. Flat savanna is found in alluvial soil from northeast down to southeast of BNP, such as Curah Udang, Asem Sabuk, Kramat, Bekol, Derbus, Palongan, Semiang, and Plalangan. Most of herbivores in the BNP (*Bos javanicus, Bubalus bubalis, Cervus rusa, Munticus muntjak)* are grazing in these savannas. Grass species dominating this savanna are *Dichantium caricosum, Heteropogon contortus, Shorgum nitidus and Schleranhne punctata.* Except some location which is very wet *Cyperus* sp instead of grasses dominates such as Semiang and Palongan savannas, while savanna Plalangan is dominated by *Imperata cylindrica*. The low water availability is only enough to support the growth of mainly grasses with short trees such as pilang (*Acacia leucophloea*), widoro bikol (*Ziziphus rotundifolia*), klampis (*Acacia tomentosa*) or kesambi (*Schleichera oleosa*).

Undulating savanna is found on rocky black soil extending from northwest along the coast of Madura Strait to the northeast facing Bali Strait. These savannas are rugged and rocky and reported less liken by herbivores in BNP. However, from our observation in the field, these areas are the grazing ground of more than 2000 local farmers' cattle. Grasses such as *D.caricosum*, *Themeda spp.,S.ritidus* and also *S. punctata* grow prolifically in between rocks on that black soil. In addition to herding their cattle to those green savanna, farmers harvest these grasses approximately 300 loads on motorbikes daily amounting to not less than 15 tons of first class fresh grasses /daily during a growing season of about 2 months from March to May. It indicates the potency of herbage production of this particular undulating savanna

2.3. Vachellia nilotica

Vachellia nilotica is the valid name of Acasia nilotica. The original *V. nilotica* seeds growing in Indonesia were introduced from Botanical Garden of Calcutta, India as reported by Teijsman (1850) and Hasskarl (1986). The import of *A. nilotica* seeds was meant as gum producers. Acacia gum contains arabic acid, an exotic compound priced highly at that time. Although the colony grew well at Bogor Botanical Garden, the production of gum was small and of low quality, and the trees were removed 40 years later (Satrapradja, 1978). But other seeds had been experimentally planted in Bali, Timor and Poso (Hellinga, 1949). *A. nilotica*, introduced to Indonesia, was considered to be subspecies *indica* (Wulyarni & Lemmens, 1991). Schuurmans (1993) on the other hand, after studying it for 10 months in Baluran was overwhelmed by the variability of the material, and suspected that *A. nilotia* was represented by the subspecies *subalata* and *adstringens* with many hybrids present in BNP. BNP functions not only as conservation area but also for providing areas for recreation, education, research to support science development, and above all to be fruitful for the surrounding people.

Introduction of *V.nilotica* to BNP likely occurred in the early 1960s (Nazif 1998). The trees were planted as fence along 1220 m with 3 m wide separating the teak forest from savanna at BNP. During dry season almost all vegetation dry out, but it is also time when the pods of *V.nilotica* ripen and drop on the dried grasses. All herbivores in the park, banteng, buffaloes, deer consume those dried nutritious pods. While pods are easily digested giving carbohidrate, lipd as well as protein the digestive tract of those herbivores do not harm *V.nilotica* seed, it is still intact and viable excreted with their feces around the park. So V*A. nilotica* and the herbivores form a mutualistic symbiosis. Those herbivores are benefitted from consuming dried pods during the dry season, and *V. nilotica* is benefitted that the seeds are distributed all over the place in the park, assissting seed dispersal considerably (BNP 2017). Rains may help the dispersion of the seed also and uncontrolled human activities within the park. The invasion of *A.nilotica* was slow initially but having gone through dry seasons the rate of invasion shoots up sharply. *A. nilotica* is well equiped to invade habitats, such as its broad environmental tolerance (Kaushik and Mandal 2005), low predation and herbivory rates (Palmer et al. 2005), mycorrhizal associations (Sharma et al. 2001), and high seed production and dispersal (Djufri 2004).

The savanna invaded by *V. nilotica* in 1993 was about 1200 ha, but in 2013 the invaded areas increased to 6.662 ha (Setyabudi et al, 2013). The invasion of *V. nilotica* indeed competed out grasses, no more grass growing in the invaded savanna, broadleaved weeds, such as *Thespesia lampas, Vernonia cymosa, Bidens biternata, Eleutheranthera ruderalis* instead, dominsting the vegetation under the invaded areas (Caesarinatika et al, 2011). In some invaded savanna shade tolerance grass such as *Oplismenus compositus* may survive (Tjitrosemito, 2015). The invasion of *V. nilotica* altered the vegetation composition from grasses, into shrubs consisting of mainly broadleaved weeds, compating out grasses. The climate change in altering the vegetation in the park was reported below (Table 4).

Table 1. Vegetation composition in Bekol savanna at the wet season of February 2013, under the medium canopy of *V. nilotica* (Tjitrosoedirdjo, *et.al* 2013).

No	**Species**	**Family**	**SDR**	**No**	**Species**	**Family**	**SDR**
1	*Achiranthes aspera*	Amarantaceae	2.86	13	*Ipomoea alba*	Convolvulaceae	6.29
2	*Aeschynomene indica*	Fabaceae	3.65	14	*Ipomoea sp.*	Convolvulaceae	2.92
3	*Bidens biternata*	Asteraceae	9.11	15	*Merremia emarginata*	Convolvulaceae	0.52
4	*Brachiaria reptans*	Poaceae	3.59	16	*Mimosa diplotrica*	Fabaceae	1.04
5	*Ceyrasia tripolia*	Vitaceae	0.69	17	*Ocimum canum*	Lamiaceae	0.57
6	*Centrosema sp.*	Fabaceae	0.56	18	*Oplismenus compositus*	Poaceae	20.9
7	*Cleome gynandra*	Capparidaceae	1.60	19	*Phyllanthus debilis*	Euphorbiaceae	0.45
8	*Commelina sp.*	Commelinaceae	0.47	20	*Phyllanthus niruri*	Euphorbiaceae	1.95
9	*Corchorus clitorius*	Tiliaceae	2.10	21	S'dling *A.nilotica*	Fabaceae	0.53
10	*Digera arvensis*	Amaranthaceae	0.45	22	S'dling *A. indica*	Meliaceae	1.38
11	*Eleutherantera ruderalis*	Asteraceae	26.0	23	*Thespesia lampas*	Malvaceae	0.95
12	*Hyptis suaveolens*	Lamiaceae	11.6	24	*Vernonia cymosa*	Asreraceae	0.55
				T o t a l			100

Table 1 indicates that the vegetation composition was dominated by herbs and shrubs such as *E. ruderalis, H. suaveolens, Bidens biternata, Achiranthes aspera, Aeschynomene indica,* even also climbing *I. alba*, leaving only less than 25% grasses *O. compositus* and *B. reptans* that were shade tolerant but less palatable to herbivores. Although the vegetation composition varied greatly under the variable *A. nilotica* canopy, a considerable proportion of herbs and shrubs was common. It was important therefore to control them to allow grasses to recover or to replant selected grasses. An experiment conducted during wet season of February 2013 application of triclopyr (formulated as GARLON 670 EC) at 1.0 lt/ha sprayed using knapsack sprayer in 400 lt water, 0.2% Agristick using T-jet nozle calibrated at High Pressure successfully controlled those herbage and shrubs (see Tbl 2).

Table 2. The efficacy of foliar spray of some selective herbicides for herbs and shrubs applied during wet season of February 2013. (Tjitrosoedirdjo, et. al. 2013).

No	Treatments	Impact on herbs and shrubs and grasses	
		Percent coverage of herbs and shrubs	Percent Coverage of Grsses
1	Fluroxypir, 0,75 lt/ha	10.58[b]	83.23[a]
2	Triclopyr, 0.5 lt/ha	21.79[b]	62.58[b]
3	Triclopyr 1.0 lt/ha	7.66[b]	80.52[a]
4	2,4-D 1.0 lt/ha	12.71[b]	78.13[ab]
5	2,4-D 2.0 lt/ha	8.69[b]	80.52[a]
6	Control	58.79[a]	32.48[c]

NB. Numbers in a column followed by the same letter did not differ significantly at 5%

The foliar application of the above herbicides were selectively killing herb and shrubs as broadleaved weeds leaving grasses intact. In fact by killing those broadleaved weeds increased the coverage of grasses. This control may be repeated several time to ensure a good control of those broadlwaved weeds which will provide a good place for planted grasses to proliferate.

When the broadleaved weeds have been eradicated or controlled and the season changes to dry season, it time to control *A.nilotica* trees. A combination of mechanical and chemical control killed trees well, and serves the prupose of eradicating the source of seeds. The trees were cut (chainsaw) below 10 cm above the ground and immediatelly brushed with 10% GARLON 670 EC(triclopyr) disolved in diesel oil killed trees and prevented the cut stump from sprouting (Table 3). This herbicide has been utilized as arboricide to kill unwanted trees.

Table 3. The sprouting percentage of *V. nilotica* stump aftter triclopyr (GARLON 670 EC) applications (Tjitrosoedirdjo, *et al.*2013)

	Treatments (Garlon 670 EC ml/l diesel oil)				
	0	15	30	60	120
% stump sprouting	63.1[a]	19.4[b]	15.5[b]	14.0[b]	6.6[c]

NB. Numbers in one column followed by the same letter didi not differ significantly at 5%

The experiments were caried out during the dry season, some trees did not sprout even when was not brushed with the solution of triclopyr in diesel oil, due to water stress. Big old trees especially, required a special attention, the solution volvume of herbicide dissolved in diesel oil was not sufficient to cover the whole cut stump and some growing points escaped herbicide molecules abd managed to sprout. It is important to ensure that the whole stump is wetted thourouhly. In some conditions inspecting the brushing must be done to ensure all tees were dead. Those timber can be taken out when the systems are organised with the local villages in the framework of immediate benefit of local inhabitant around the park.

Broadleaved weeds should be controlled during the wet season when trees of *V.nilotica* are still standing. Those broadleaved weeds are more susceptable under the shade of *V.nilotica* canopy and more comfortable for workers.

2.4. Taxonomical Consideration

V. nilotica is the new correct name of *Acacia nilotica*, after an intensive review by Maslin (2015). *Acacia* genus covers 1350 species distributed in tropical and sub-tropical regions found in all continents accept in Antartica. The recent research discoveries on molecular phyllogenetics revealed new facts and understanding that Acacia is *polyphyletic*. The original description of Acacia by Miller (1754) was so diverse, so inconsistent, producing a genus as a collection of plants with a great variations and they were polyphyletic. Bentham (1875) in his *magnumopus* not only redefining *Acacia*, but also improving internal classification, fifteen genera were described as con-generic of *Acacia sensu lato*. Since 1986 an extensive comparative molecular studies based on the analyses of chloroplast and nucleus DNA provided convincing evidence to decide a strong informative decision on the phyllogenetic and classification of *Acacia*. The studies included not only *Acacia sensu lato* and *Faidherbia* A. Chev. (together including *Acacieae* tribe) a more important one, also included representation of *Ingeae* and *Mimosea* tribe. These studies demonstrated that *Acacia sensu lato* was *polyphyletic* consisting of 5 monophyletic groups which each warrant recognition as a distinct genus. These 5 genera are:

1. Two small endemic genera of new worlds, *Acaciatella* (resurrected by Rico Arce and Bachman, 2006) and *Mariosousa* (new genus described by Siegler et al, 2006).
2. Two relatively large genera of pan-tropical region, *Senegalia* (resurrected by Pedley, 1986) and *Vachellia* (containing the species tipe, *Acacia nilotica* (L.) Willd ex Dell and
3. Enormous genus mostly Australian, *Acacia sensu stricto* (Syn. *Racosperma*)

2.5. Grasses

Grasses are the main vegetative componence of savanna that suffered from the most damaging impact of *A.nilotica* invasion. In Bekol savanna, the pasture consisting of *Dichantium caricosum, Heteropogon contortus, Shorgum nitidus and Schleranhne punctata.Brachiaria reptans* their population were reduced and the grass vegetation was altered into shrubs dominated by *Thepesia lampas, Vernonia cymosa, Bidens biternata,* and *Flemengia lineata* the last one was broadleaved weeds with a very intensive network systems of under ground stolon, very difficult to control.

There are 2 types of photosynthetic pathways in grasses, i.e C3 and C4 pathways. In the C3 pathway, CO_2 is fixed in mesophyl cells by ribulose-1, 5-bis-phosphate caboxylase, and strach is formed in the same chloroplast. In the C4 pathway CO_2 is fixed by phosphoenol pyruvate (PEP) carboxylase in the cytoplasma of mesophyll into oxaloasetate which is reduced to malate or transamina ted to aspartate. These substances are transported into the bundle sheath cells. Here CO_2 is generated by a decarboxylation process and refixed by ribulose -1, 5-bis phosphatase (RuBP) carboxylase. The previous fixation by PEP caboxylase in the mesophyll cells probably function as a mechanism for concentrating CO_2 in bundle sheth cells to inhibit RuBP oxygenation. This allows RUBP carboxylase to work efficiently even with low CO_2 concentration in the intercellular space of the leaf sheath (Thompson and Estes,1986). C4 plants therefore have higher photosynthetic rate than that of C3 plants.

The indegenous grass *D.caricosum* in the savanna when invaded by *A.nilotica* was compated out so severe, even when the savanna was managed the population of this indegenous grass was extremely low. (Table The invasion of *A.nilotica* also provide an environment conducive to the luxurious growth of broadleaved weeds. The increase in [CO_2] benefits more on broadleaved weeds than C4 grasses. Under full sunlight at a high range of temperature, with low soil water availability, C4 grasses easily beats the seedlings of those weeds, which succumbs to death due to low soil water availability and high sunlight intensity. The situation is changed under this climatic changes as it is now. With those background information this proposal is submitted for completing the component to develop the best manageent practices to rehabilitate the degraded savanna in the Baluran Park.

The table below shows how serious is the impact of *V. nilotica* invasion. The table shows clearly that when savanna was invaded no grasses was recorded, the vegetation was dominated by *A.nilotica* with 63.3 % . The area represented an area where *V. nilotica* trees were harvested by cutting about 50 cm above the ground and left without further treatments.

The cut stump resprouted with 3-7 new sprouts forming a close canopy o *V.nilotica* trees, no grass was recorded, but broadleaved weeds.

Table 4. Species structure and composition of the three vegetation types, as reflected by relative density (RD), relative frequency (RF), and importance value index (IVI) values.

Family	Species		Uninvaded area			Invaded area			Managed area		
			RD (%)	RF (%)	IVI (%)	RD (%)	RF (%)	IVI (%)	RD (%)	RF (%)	IVI (%)
Malvaceae	*Thespesia lampas*	*	31.9	20.0	51.9	18.1	26.6	44.8	47.0	15.5	62.6
Maranthaceae	*Achyranthes aspera*	*	0.6	4.0	4.6	11.6	13.3	25.0	0.5	4.3	4.9
Asteraceae	*Veronica cinerea*	*	23.8	20.0	43.8	-	-	-	28.2	15.5	43.7
Apiaceae	*Centella asiatica*	*	3.7	16.0	19.7	-	-	-	6.0	15.5	21.6
Poaceae	*Dichanthium caricosum*	*	36.3	20.0	56.3	-	-	-	4.5	3.1	7.6
Meliaceae	*Azadirachta indica*	*	0.4	4.0	4.4	-	-	-	0.1	1.8	2.0
Rhamnaceae	*Ziziphus rotundifolia*	*	0.2	4.0	4.2	-	-	-	0.3	4.3	4.6
Asteraceae	*Ageratum conyzoides*	*	**2.5**	**8.0**	**10.5**	-	-	-	-	-	-
Cucurbitaceae	*Citrullus vulgaris*	*	0.2	4.0	4.2	-	-	-	-	-	-
Sapindaceae	*Schleichera oleosa*		-	-	-	-	-	-	**7.1**	**14.9**	**22.1**
Fabaceae	*Phaseolus* sp.		-	-	-	-	-	-	**1.0**	**4.3**	**5.3**
Malvaceae	*Abutilon crispum*		-	-	-	-	-	-	**0.3**	**4.3**	**4.6**
Malvaceae	*Thespesia* sp.		-	-	-	-	-	-	**1.6**	**3.7**	**5.4**
Laminaceae	*Ocimum sanctum*		-	-	-	0.3	6.6	6.9	0.0	0.6	0.6
Leguminoceae	*Acacia leucophloea*		-	-	-	-	-	-	0.0	1.2	1.3
Leguminoceae	*Acacia nilotica*		-	-	-	63.3	33.3	96.6	2.6	10.5	13.1
Amaranthaceae	*Cyathula geniculata*		-	-	-	**6.4**	**20.0**	**26.4**	-	-	-
Total			100.0	100.0	200.0	100.0	100.00	200.0	100.0	100.0	200.0

See the text for explanations of RD, RF, and IVI. Asterisk character shows species that are native to savanna ecosystem. Bold values indicate site-specific species.

Ref. E. Caesariantika, T. Kondo, N. Nakagoshi . 2011. Impact of *Acacia nilotica* (L.) Willd. ex Del invasion on plant species diversity in the Bekol Savanna, Baluran N P., East Java, Indonesia, TROPICS 20 (2): 45-53.

2.6. Banteng (*Bos javanicus* D'alton)

The invasion of prickly acacia is one of the several factors that contribute to the decline of ungulate diversity and population (Setiabudi *et al.* 2013). The tree suppresses the growth of grasses (Tjitrosoedirdjo *et al.* 2013) which leads to the reduction of flora diversity and abundance (Caesariantika *et al.* 2011). The reduction of grass biomass (Qirom *et al.* 2007) and productivity (113 kg/day) is lower than the standard (150 kg/day) (BNP 2006c). This reduction severely affects forage quantities for ungulates. Although there is no research directly linking grass biomass and ungulates' population decline, there is evidence that supports the hypothesis that ungulate population decline correlates with an increasing spread of prickly acacia. Prior to the invasion (in 1965), 250 bantengs were recorded in BNP. This number declined to between 161 and 194 individuals in 1984 (Sugardjito 1984). In 2011 there were only 22 banteng left and the species is predicted to go extinct by 2050 (Hakim et al. 2015).

3. METHODOLOGY

The damages caused by biological invasion of plants have been increasing considerably The experts in the world have been traying to find the solutions among others by organizing a workshop in June 2014 in Benasque, Spain. One outstanding recommendation was that the problems must be solved through transdicipline approach as described in the objectives of these works involving 9 components. This Research is to complete the component the best practices of savanna rehabilitation to prevent the extinction of banteng and recovering the deteriorating biodiversity in this Baluran National Park.

3.1. Collection Of Prospective Grasses And Noxious Broadleaved Weeds

Prospectives grasses are those grasses reported to be dominating in both undulating and flat savanna before the invasion of *A.nilotica*. These are *Dichantium caricosum, Heteropogon contortus, Shorgum nitidus and Schleranhne punctata. Themeda sp., Brachiaria reptans,* and *Oplesmenus compositus.* These grasses and other noxious broadleaved weeds such as *Vernonia cymosa, Thespesia lampas, Flemengia lineata, Eleutheranthera ruderalis,* are collected and grown in the green house in green- house and field site of SEAMEO BIOTROP, Bogor.

Collections were conducted twice in 8-9 June 2021 and 18 September 2021. In June 2021 collections were conducted at, Bekol, Karangteko and Batu Hitam. Two species of grasses *Heteropogon* sp and *Dichantium* sp. were collected planted at the field site of SEAMEO BIOTROP. Seeds were also collected from Karangteko.

The mature spikelet carrying caryopsis of those grasses were harvested individually, collected in paper bags with written name, date, place of collection and name of collector to ensure the identification of the species. These spikilets carrying caryopsis are brought to the laoratory, and air dried on the flat bamboo strays seperated one from di other to prevent caryopsis from mixing one species with another. The dried caryopsratiois are stored in dried small containers for further activities. The germinated seeds were transplanted to plastic pot and after flowering, some plants were prepared as herbarium specimens. The duplicate specimens were sent to Herbarium Bogoriense to be identified.

Three species of grasses, *Dichantium* sp., *Brachiaria* sp. and *Polytrias* sp. Were collected in 18 September at road site to Batu Hitam. The grasses were placed at the plastic bags containing soil and compost. The grasses were sent to Bogor and cultivated at the green house.

3.2. Photosynthetic Measurement

Three caryopsis of each species are sown in small plastic pots containing soil mixed with compost at 2:1 ratio, moistened daily to germinate in the green house at BIOTROP compound. After one month growth photosynthetic measurement are to be conducted.

The measurement of photosynthesis were carried out using the Photosynthetic Gas Exchange Analyser LICOR LI-6400. To analyze the photosynthetic light curve, photosyntheis measurement were carried out at different light intensity 50, 100, 200, 400, 800 and 1600 µmol/m2/s. The different in light ressponse may seperate them between C3 and C4 plants.

3.3. Competition Studies

A greenhouse experiment was organized to study the competition ability between grasses of *Dichantium caricosum* and *Vernonia cymosa* were conducted at SEAMEO BIOTROP greenhouse in October to December 2021. *D. caricasum* is an important grass for herbivores while *V. cymosa* an important weed at Baluran savana. The seeds of *D. caricosum* and *V. cymosa* were collected from Bekol Savana, Baluran National Park. The seeds were spread at the plastic pot of 25 cm height and 30 cm in diameter. The design of the experiment was Randomized Blok Design with grasses *D. caricosum* as and *V. cymosa*

The treatments of the experiments were as follows:

D12 V0 = 12 *D. caricosum* plants

D9 V3 = 9 *D. caricosum* and 3 *V. cymosa* plants

D6 V6 = 6 *D. caricosum* and 6 *V. cymosa* plants

D3 V9 = 3 *D. caricosum* and 9 *V. cymosa* plants

D0 V12 = 12 *V. cymosa* plants

There were 4 replicates for each of the treatment. After 50 days all the plants were harvested and measuring dry weight of roots and above ground parts.

Figure 2. a. Germinated seeds *Dichantium caricosum* and *Vernonia cymosa* for competition studies; b. Planting the seedling into pot; c. Harvesting *Dichantium caricosum* and *Vernonia cymosa.*

It is recognised that any plants living in a certain environment its growth is limited by the carrying capacity of the environment in other words the plant will reach a maximum biomass and can not anymore increase that carrying capacity, in some textbook it is called constang final yield and is describe as a hyperbolic curve and express mathematically as θ = { βz /(βz + 1)}**Ω**, , θ = dry weight; z = density; **Ω** = a maximum value of dry weight that may be achieved , and β = capacity to compete, when it is expressed graphically it looks like Fig.2 (A).

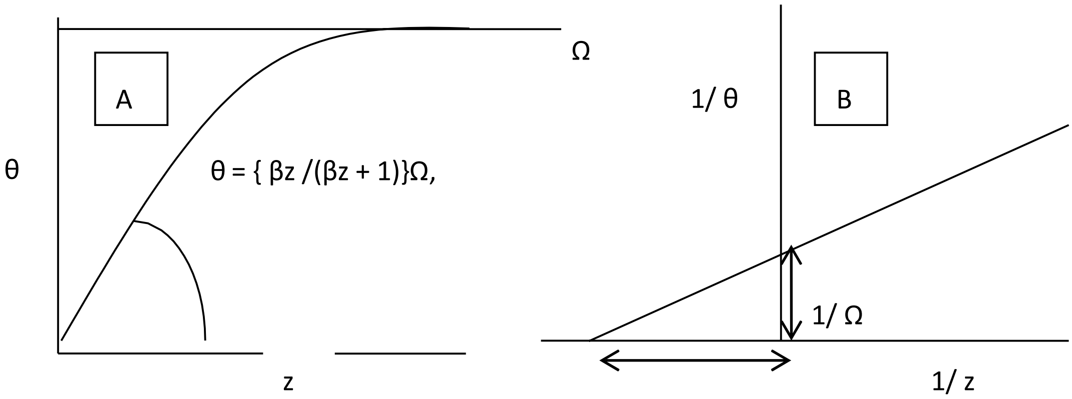

Figure 3. Graphical realtionship betweeen biomass (dry weight) and density forming hyperbolic relationship, θ = { βz /(βz + 1)}**Ω**, as can be observed here **Ω** is the asymptot of this expression or may be interpreted **Ω** as carrying capacity of the environment.

The above expresssion may be made into its repciprocal becoming 1/ θ = (βz + 1)/ βz **Ω** 1/ θ = 1/ **Ω** + 1/β.1/ **Ω**.1/z, and when 1/ θ dan 1/z considered as y dan x, 1/ **Ω** is a constant that may be called as"a" and 1/β.1/ **Ω** considered as "b" or slope of this linier equation, then we have $y = a + bx$ (Figure 2(B). This linier equation is eassily worked out as y is only the reciprocal of dry weight (1/y) and x is the reciprocal of density (1/x).

The experiment will be conducted with 4 differeent densities, i.e 2, 4, 8, 16 seeds/pots replicated 6x. The plants are harvested after 4 months, and the competitive ability (β) will be wrked out accordingly.

Competition studies using replacement model assumes field area is divided into uniform small quadrats measuring "m" m^2,and each quadrat is planted with a seed of our experimental plants. For example we plant species 1 as S1 and species 2 as S2, the number is Z1 for species 1 and Z2 for specie 2. The total fraction of sspecies1 and species 2 and 1.

Area that are plssnted species S1 is A1

Area planted with sspecies 2 is A2, A1 + A2 = 1

And the area planted are mZ1 + mZ2 + 1 or m(Z1 + Z2) + 1

If these planted plants do no compete each other , the dry wight of each will be

$\Theta_1 = \{Z_1/ (Z_1 + Z_2)\}\ M_1 = z_1\ M_1$

$\Theta_2 = \{Z_2/(Z_1 + Z_2)\}\ M_2 = z_2\ M_2$

So : $\Theta_1 + \Theta_2 = z_1\ M_1 + z_2\ M_2 = z_1\ M_1 + z_2\ M_1 - z_2\ M_{1\ +}\ z_2\ M_2$

$= M_1\ (z_1 + z_2) - z_2\ (M_1 - M_2)$

$= M_1 - z_2\ (M_1 - M_2)$

M_1 and M_2 are dry weght of S1 and S2 in monoculture

If there is a competition the performance of each species depends upon their activities.

For example the activity is given as b_1 for S1 and b_2 for S2, .then

$A_1 = Z_1/ (Z_1 + Z_2\ )$ become $b_1Z_1/ (b_1Z_1 + b_2Z_2\ )$, and

$A_2 = Z_2/ (Z_1 + Z_2\ )$ become $b_2Z_2/ (b_1Z_1 + b_2Z_2\ )$,

therefore

$\Theta_1 = \{Z_1/ (Z_1 + Z_2)\}\ M_1$

$= \{b_1Z_1/ (b_1Z_1 + b_2Z_2\ )\}\ M_{1,\ \text{and}}$

$\Theta_2 = \{Z_2/(Z_1 + Z_2)\}\ M_2$

$=\{b_2Z_2/ (b_1Z_1 + b_2Z_2\ )\}\ M_2$

In this competition, the crawding coeffient or competitive coefficient is calculated among the competing species, if we called k1.2 is the crawding coefficient of S1 to S2 and k2.1. species 2 to species then $k_{12} = b_1/ b_2$ and $k_{21} = b_2/ b_1$ then

$\Theta_1 =\{(b_{1/}\ b_{2)}Z_1/ (b_{1/}\ b_{2)}Z_1 + Z_2\ )\}\ M_1$

$= k_{12} Z_1/(k_{12} Z_1 + Z_2) M_1$, we can work out to fine k1.2., this expression can be worked out , tobecome

$\Theta_{1=} k_{12} Z_1/(k_{12} Z_1 + Z_2) M_1$

$\Theta_1(k_{12} Z_1 + Z_2) = k_{12} Z_1 M_1$

$\Theta_1 k_{12} Z_1 + Z_2 \Theta_1 = k_{12} Z_1 M_1$

$k_{12} Z_1 M_1 - \Theta_1 k_{12} Z_1 = Z_2 \Theta_1$,

$k_{12} (Z_1 M_1 - \Theta_1 Z_1) = Z_2 \Theta_{1,}$

we can get this formula for crawding coefficient

$$k_{12} = \boxed{Z_2 \Theta_1/ Z_1(M_1 - \Theta_1)}$$

The experiment with replacement series may be done using simple design of consingting of

S1and S2 in the combination as the following (0+12, (3+9). (6 +6), (9 +3). (0+12) replicated 6 times, subjest to the availability of viable seeds collected from the field.

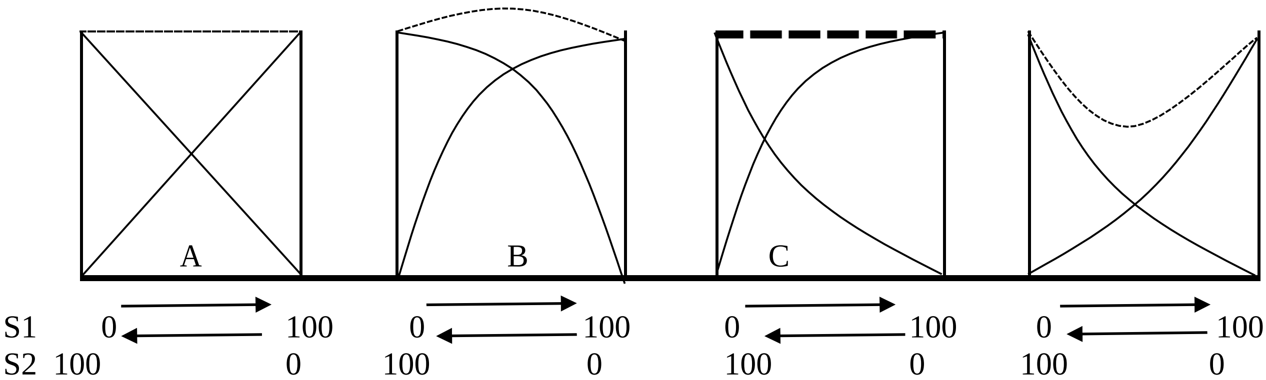

Figure 4. The results can be assumed to be A (no competition), B (symbiosis), C (competition), D (antagonist).

4. RESULTS AND DISCUSSIONS

4.1. Collection of Prospective Grasses and Noxious Broadleaved Weeds

There are 9 grasses and 1 species of broad leaves weeds collected at Baluran National Park. All them has been identified up to genus level, and in the process of identifying to species level. *D. caricosum* and *Vernonia cymosa* is still verified for the valid species name. Collection of the grasses, broadleaves and seeds were conducted twice, in June and September 2021. The first collection in June 2021 the grasses look green after 3 days raining. However other shrubs and broadleaves just begin to regrowth after dry condition for several months. Only 2 species of grasses could be collected *Heteropogon* sp. and *Dichantium caricosum* (Figure 5). *Heteropogon* sp. was collected from Batu Hitam and from Bekol. Both species could grow well at the field site of SEAMEO BIOTROP. Seeds were collected from Karang Teko, Bekol and Batu Hitam. The seeds were grown at the laboratory and the seedling were transplanted to plastic pot containing soil and humus. These growing seeds of grasses and broad leaves were used for competion experiments. The second collection in September 2021, vegetations look green, grasses, shrubs and trees. Three species of grasses were collected at the road site to Batu hitam, *Brachiaria* sp., *Dichantium* caricosum (lamuran putih)., and *Polytrias* amaura (*lamuran merah*). These grasses were cultivated at the SEAMEO BIOTROP green house and used for photosynthetic experiment. Seeds were also collected from Karang Teko and Bekol. The specimens of collected grasses and broad leaves were send to Herbarium Bogoriense, Cibinong for further identification to species level.

Figure 5. *Dichantium caricosum* (Lamuran) and *Heteropogon* sp. were planted in the garden of SEAMEO BIOTROP (the photo was taken when the plants were 2 months old after collection).

4.2. Photosynthesis Measurement

Dichantium caricosum was reported since 1933 as a grasses for animal feeds in Australia, South Africa, USA, India and the Philippines (Bisset & Sillar, 1984; Wied et al 2021). *Dichantium* is a grasses species belong to C4 photosynthesis (Soreng et al 2015), while *Vernonia cymosa* a broad leaves belong to C3 photosynthesis. Bekol savanna at Baluran National Park has a dry climate and 8 months dry season, C4 is more efficient than C3 because there is no photo respiration occurred. Photosynthesis running quickly when more light intensity and high temperature during the dry season and plenty of oxygen. C4 plant has high CO_2 concentration in all part of the leaves, no photorespiration and can close their pores for long period of time. These factors preventing the plant from water loss. *D. caricosum* can survive during the dry season with only 700 mm rain fall/year. *D. caricosum* could be cultivated as a good forages for herbivores at Baluran National Park. The results of the photosynthesis measurement are still tested and analyses at IPB Laboratory.

4.3. Competition Studies

One of the factor reducing the banteng population at Bekol Savana from time to time is the invasion of *Vachelia nilotica*. *V. nilotica* significantly reducing the grasses population of the savanna and grazing areas of banteng. Climate change increasing atmospheric CO2, is not only effecting the grasses but also facilitating the growth of broad leaves such as *Bidens biternata*, *Eleutherantera ruderalis*, *Vernonia cymosa*, *Thespesia lampas* and other species. These broad leaves competing with the grasses under the shade of *V. nilotica* and reducing the grasses for herbivores.

Lamuran putih (*Dichantium caricosum*) one of the grasses preferences by herbivores such as deer and banteng, it could grow throughout the year. The grasses have a good nutritive value, 15.58% protein, 2.18% fat and 34.51% fibers (Garsetiasih, 2015). Lamuran is a good grass for herbivore and recommended animal feeds at Baluran National Park. However not only *V. nilotica* competing with *D. caricosum* a broad leave weed *Vernonia cymosa* is also competing with *D. caricosum*. In this studies

Competition replacement series of de Wit (1960) is aimed at studying inter-specific competition between *D. caricosum* and *V. cymosa*. Competition ability can be predicted by dry weight of the mix planting. The research prediction on the competition of *D. caricosum* and *V. cymosa* can be shown by biomass percentage (biomass) from the mix planting. Chart analysis related with competition indicated that the same density (6:6), the competition of *D. caricosum* was lower than *V. cymosa* (Figure 6). It can be seen by the biomass percentage of *D. caricosum* lower than *V. cymosa*, the biomass percentage of above ground parts, root, and the biomass percentage of the whole plants (Figure 6).

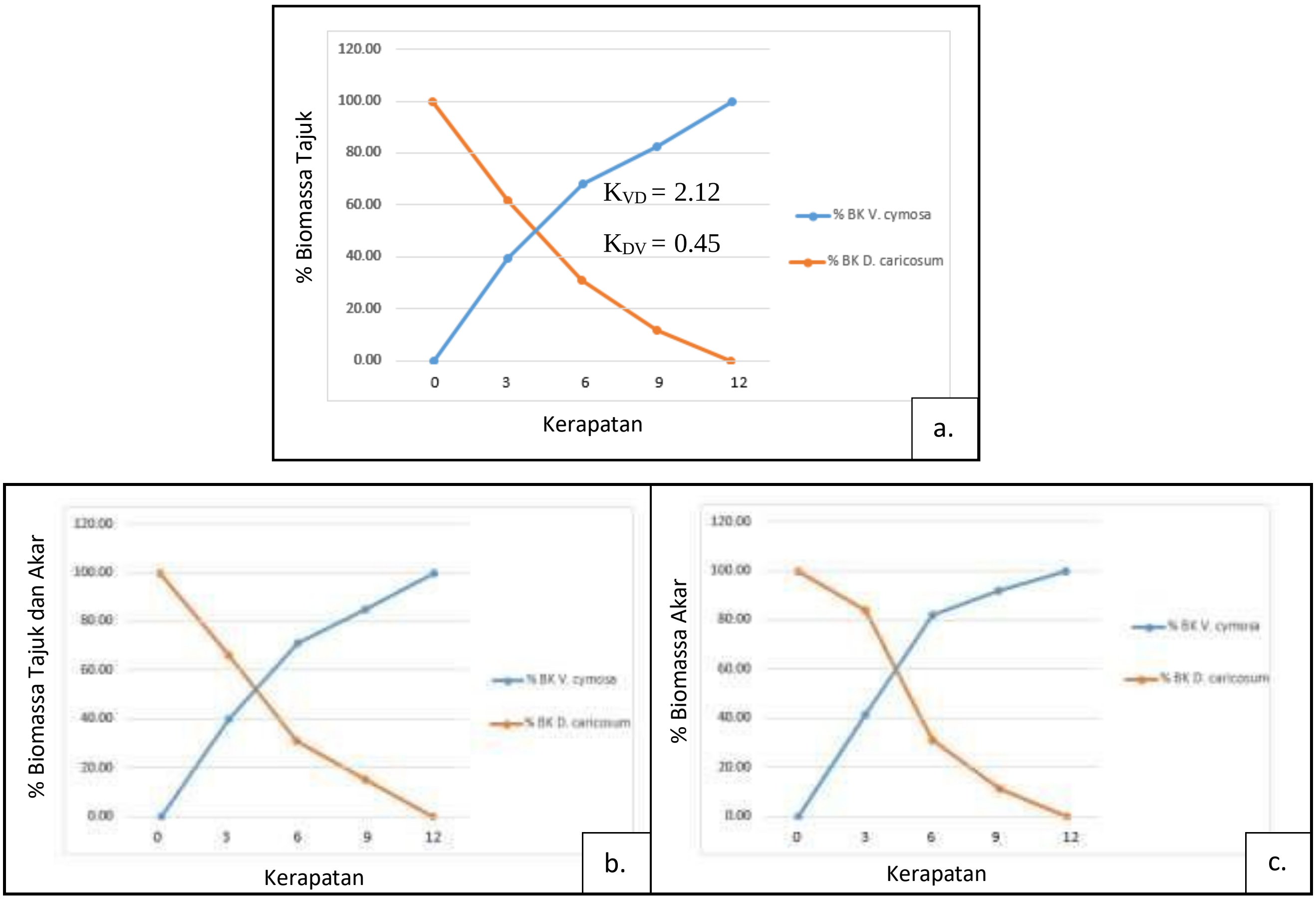

Figure 6. Competition chart between *Dichantium caricosum* and *Vernonia cymosa* 50 days DAP (days after planting): a. Relation chart between above ground biomass and their density. b. Relation chart between above ground biomass and roots density. c. Relation chart of root biomass and its density

In addition, the graphics is consistent with the results of the relative crowding coefficient. Relative crowding coefficient is a value of measuring plant competitive ability. A plant having high relative crowding coefficient showing the high competitive ability (Utomo *et al*, 2007). The value of relative crowding coefficient was obtained from the same planting ratio (6:6) of *D. caricosum* and *V. cymosa*. The analysis shows that *V. cymosa* competing *D. caricosum*. The value of relative crowding coefficient of *D. caricosum* (K_{DV} = 0.45) is less than *V. cymosa* (K_{VD} = 2.12) as shown by Figure 6a.

Nyawon (*Vernoia cymosa*) is one of the 22 invasive plants at Baluran National Park (Susilo et al, 20200. Weed's shrubs are an important weed at Bekol Savanna, due to its fast growth and strong rooting system (Djufri, 2013). Grasses as herbivores feeds suffering from the shrubs in getting light from the sun, and the nutrition. If there are no efforts to control *V.*

cymosa, the grasses areas will be replaced by *V. cymosa*. The grasses production and less carrying capacity of the savanna for herbivores grazing and less food for herbivores. If there is no effort controlling the shrubs, grasses will be replacing by shrubs and will changes the ecosystem of the savanna by bushes and further into secondary forest. This situation will give limiting carrying capacity of the savanna in providing the grazing ground for herbivores at Baluran National Park.

5. CONCLUSIONS

There are 9 grasses and 1 species of broad leaves weeds collected at Baluran National Park. All of them has been identified up to genus level, and in the process of identifying to species level. *D. caricosum* and *Vernonia cymosa* is still verified for the valid species name. *Dichantium caricosum* is a grass recommended to be cultivated at Baluran National Park due to the high survival rate during the dry season. *V. cymosa* has a high competition ability than *D. caricosum*. *V. cymosa* has to be controlled to save the growth of *D. caricosum.* Good pasture of Baluran National Park dominated by *D. caricosum* will save the herbivores especially banteng and deers in grazing their feeds.

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