Resistance Screening Trials on Coconut Varieties to Cape Saint Paul Wilt in Ghana

Sélection de Variétés Résistantes a la Maladie de Cap Saint Paul au Ghana

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Abstract:
The Cape St. Paul Wilt Disease (CSPWD), is a 'coconut lethal yellowing-type' disease (LY), and is the single most serious threat to coconut cultivation in Ghana. The recommended disease management strategy is the cultivation of disease-resistant coconut varieties. More than 38 varieties have been screened for their resistance to CSPWD since 1956 and the results are reviewed in this paper. Two varieties, Sri Lanka Green Dwarf (SGD) and Vanuatu Tall (VTT), have shown high resistance to the disease, and their hybrid (SGDxVTT) is under observation to determine its performance. A programme to rehabilitate the CSPWD- devastated areas was started in 1999. Emerging results indicate that the MYDxVTT hybrid being used for the programme, succumbs to the disease under intense disease pressure. A redirection of the rehabilitation programme and the screening of more varieties are recommended.
Key Words: Ghana, Cape St. Paul wilt disease, coconut, varieties, resistance screening.

Résumé:
La maladie du cocotier de Cap Saint Paul (CSPWD), signalée pour la première fois au Ghana en 1932, est une maladie du type jaunissement mortel. C'est la plus sérieuse menace pour le cocotier dans le pays. La stratégie de lutte recommandée dans le monde est la culture de variétés de cocotier résistantes à la maladie. Plus de 38 variétés ont été éprouvées depuis 1956 pour leur résistance au CSPWD et les résultats sont mentionnés dans cet article. Deux variétés, le Nain vert de Sri Lanka (NVS) et le Grand du Vanuatu (GVT), ont montré une grande résistance à la maladie, et les caractéristiques agronomiques de leur hybride SGD x VTT sont en cours d'évaluation. Un programme de replantation des zones dévastées par la maladie a débuté en 1999. Il est apparu que l'hybride MYD x VTT utilisé dans ce programme, a été infecté suite à une forte pression de la maladie. Une nouvelle orientation du programme de replantation et la sélection d'autres variétés ont été recommandées.
Mots clés: Ghana, maladie de Cap St. Paul, cocotier, variétés, résistance.

Resumen: "Pruebas de Selección de Resistencia del Marchite de Cape Saint Paul de los Cocoteros en Ghana"
La enfermedad de marchite del Cape St. Paul (CSPW) es una enfermedad del tipo amarillamiento mortal del cocotero (LY), y es la más seria amenaza para el cultivo del cocotero en el país. La estrategia de lucha recomendada en el mundo es el cultivo de variedades de cocotero resistentes a la enfermedad. Más de 38 variedades han sido seleccionadas por su resistencia al CSPW desde 1956 y los resultados son revisados en este informe. Dos variedades, la Sri Lanka Green Dwarf (SGD) y la Vanuatu Tall (VTT), han mostrado gran resistencia a la enfermedad, y sus híbridos (SGDxVTT) están bajo observación para determinar su rendimiento. En 1999 se empezó un programa para rehabilitar las zonas devastadas por el CSPW. Los resultados emergentes indican que el híbrido MYVxVTT utilizado en el programa, sucumbe a la enfermedad bajo una presión intensa de la misma. Se recomienda un cambio de dirección en el programa de rehabilitación y la selección de más variedades.
Palabras clave: *Ghana, enfermedad de marchite de Cape Saint Paul, cocotero, variedades, selección a la resistencia.*

Introduction.

The coconut palm (*Cocos nucifera L*) is the 'main stay' of the economies of the coastal belt of Ghana (Adams *et al*, 1996; Dery *at al*, 1996). Due to the poor edaphic factors of this zone, coconut is usually the only crop that is commercially exploitable here (Dery *et al*,1996). The ability of the crop to create employment and spread wealth is common knowledge in the southern part of Ghana. It is, therefore, a major concern that the coconut industry in Ghana is threatened by the Cape St Paul wilt disease (CSPWD).

The CSPWD belongs to a group called lethal yellowing (LY), which also occurs in Togo, Nigeria, Cameroun, Tanzania and the Caribbean (Eden-Green, 1995). LY is known to be caused by phytoplasmas (non-culturable obligate parasites) and believed to be transmitted by insect vectors, notably plant and leaf hoppers (Homopterans)(Howard *et al*., 1983; Hunt *et al*., 1974).

CSPWD was first reported in the country in 1932 at Cape St Paul in Woe in the Keta area of the Volta Region (Chona and Addoh, 1970). By 1934, 21 palms had been affected, the number rising to 476 by 1938 and in less than 10 years after its detection, it attained epidemic status, destroying about 9 % of the coconut palms in that region (Chona and Addoh, 1970). The disease next appeared in Cape 3 Points in the Western Region, about 450 km from the initial focus, in 1964 (Chona and Addoh, 1970 and Addison, 1980). The disease was confined to this area for about 5 years, before starting a rapid spread in an east-north direction, and a rather slower westward spread (Chona and Addoh, 1970); and appeared at Ayensudo in the Central Region in 1983 (Ofori and Nkansah-Poku, 1995).

The rapid spread of the disease from the initial focus in the Keta area and its devastating effect, made CSPWD the single most serious threat to the coconut industry, prompting the Dept of Agric of the Gold Coast to initiate scientific investigations into the disease in 1942. However, unable to determine the cause and mode of spread of the disease, it was concluded that, search for resistant coconut varieties was the best option to follow (Chona and Addoh, 1970). Consequently, resistance screening was commenced in 1956. This research effort has been continued by various scientists, authorities and funding agencies up to the present time. The outcome of these trials up to 1995, led to the recommendation of the SGD, VTT, SGDxVTT and MYDxVTT as suitable materials for rehabilitating the devastated areas (Dery *et al*, 1995). At the time, only the MYDxVTT was readily available to be multiplied and released for the rehabilitation programme, even though its resistance level was not the best.

Emerging results now show that the MYDxVTT succumbs under intense disease pressure, thus calling for a redirection of the rehabilitation programme. Past results of the resistance screening trials have been published by various authors at different times. This paper seeks to review the past results of the resistance screening trials in Ghana, update the results of the current trials, and discuss the prospects for future resistance trials and rehabilitation programme.

1. The highlights of past resistance screening trials

1.1. Trials of 1956 / 57 and 1966 / 69

The Department of Agriculture established resistance screening trials at Ohawu, Dzelukope, Tegbi and Cape St. Paul in the Keta area of the Volta Region in 1956/57. The varieties tested were Malayan Yellow Dwarf (MYD) and Malayan Green Dwarf (MGD), obtained from Malay (now Malaysia) and progenies of some West Africa Tall (WAT) that had survived in CSPWD devastated areas (Chona and Addoh, 1970; Addison, 1980). Except for the Dzelukope trial, all the other trials were abandoned due to heavy losses of the test palms. Initially, the MGD appeared to be less susceptible, but after the disease had run its full course, it became obvious that the MGD, MYD the WAT were all susceptible to CSPWD (Table 1).

Table 1: Disease incidence in resistance trials at Dzelukope (1956/57 planting).

Variety	No. of Test Palms	Disease Level (%)				
		Mar 65	Jun 65	Feb 66	Dec 66	Feb 77
MGD	10	8.3	8.3	50.0	92.0	100
MYD	24	33.3	45.8	70.8	96.0	100
WAT	33	42.4	48.5	87.8	91.0	**

** not available. Source: Computed from Chona & Addoh, 1970 and Addison, 1980.

Since the Malayan dwarfs were resistant to LY in Jamaica, it was opined that either LY and CSPWD were different diseases or that the MGD and MYD tested were not 'true to type'. Consequently in 1966, further screening was continued at Dzelukope with two introductions in 1964 and 1966 with 'certified materials' (Table 2). Flood-destruction of most of the test palms necessitated the repeat of the experiment in 1969. Similar to the previous trial, all the varieties eventually succumbed to the disease, proving that dwarf varieties that had proven resistant to LY in Jamaica, were susceptible to CSPWD at Dzelukope. Addison, (1980) and Harries, (1995), were of the view that the environmental conditions at the Dzelukope area could have made the test palms exceptionally susceptible to the disease. Harries (1995) recommended that the Western Region should be the area to consider for resistance trials and that the Malayan dwarfs be re-considered for testing.

Table 2. Disease incidence in resistance trials at Dzelukope (1967/69 planting).
**not available. Source: Computed from Chona & Addoh, 1970; Addison, 1980 and Harries, 1995).

Variety	Source	No. Planted	No. Established	Resistance Rating
1964 Introductions				
MYD	Ivory Coast	**100**	**8**	Highly susceptible
MGD	Ivory Coast	**100**	**14**	Highly susceptible
CRD	Ivory Coast	**100**	**9**	Highly susceptible
1964 Introductions				
WAT	Keta	**	**3**	Highly susceptible
MYD	Jamaica	**60**	**14**	Highly susceptible
MGD	Jamaica	**60**	**14**	Highly susceptible
MRD	Jamaica	**60**	**15**	Highly susceptible

1.2. The 1977 Trials.

Following from the Dzelukope experience, the Crop Research Institute planted a trial in 1977 at Cape 3 Points in the Western Region, which had been an active disease focus since 1964 (Addison, 1980). The varieties tested were Malayan Red Dwarf (MRD), MYD and MGD from certified LY-resistant mother palms in Jamaica, and WAT (as susceptible control). Some few *Veitchia* and *Phoenix* species were included in the trial. Also some wild oil palm undergrowths were inadvertently left to grow with the test palms. All the coconut palms were killed by the disease, but the other palm species survived (Addison, 1980).

1.3. The 1981-1983 Trials.

Between 1981 and 1983, the Ministry of Agriculture, funded by the French Government under the France-Ghana-Ivory Coast Project, established 7 resistance trials in the Western Region, using 27 varieties (de Taffin and Le Saint, 1987). Situational reports of these trials have been published by Dery *et al*, 1995; Mariau *et al*, 1996; Dery *et al*, 2000 and Dery *et al*, 2008, and updated in this paper. It took variable period of field exposure to effect disease in the affected plots. The Axim trial was affected after more than 20 yrs of planting, whereas Prince's (Princess) Town trial registered 1 death after 15years of exposure, after which the disease has been dormant for the past 10 years. After 27 years of exposure to infection, the Dadwen trial is still 'disease-free'

With the exception of the Cape 3 Points and Prince's Town trials, disease in all the affected trials entered into a dormant phase after a certain period of attack. At Akwidae the dormant phase occurred 14 years after attack when disease level was 66%. At Agona Junction it was 6 years of attack with disease level at

65% and at Axim it was 4 years of attack with disease level at 83%. The single death registered at Prince's Town was not confirmed by lab test, could possibly be a wrong diagnosis. The Cape 3 Points location has always been an active disease focus with no dormant period reported. The performance of the varieties screened in the 1981/83 trials is summarized in Table 3. The resistance of the ecotypes and hybrids were rated according to the scheme of Been, 1981. From all the trials, it was only at the Axim trial that 1 SGD palm died of CSPWD. It was also at this plot that all the VTT palms were killed by the disease. The SGD and VTT palms at the Axim plot, however, showed abnormal growth habits, as evident in Plate 1. Previously 1 VTT palm at the Dixcove trial had succumbed to CSPWD, but it was after it had been scorched by fire (Dery *et al*., 2008).

1.4. The 1995 Trials.

The CSIR-Oil Palm Research Institute, with funding from EC-STD III, planted 2 trials in 1995, one at Tumentu with 11 varieties and the other at Cape 3 Points (at the old trial plot) with 8 varieties. The Tumentu plot is still 'disease-free' but the Cape 3 Points plot was attacked in 2004 (9 years after planting). Situational report on this trial, up to April 2006 has been published (Dery *et al*, 2008). Table 4 is an update of the disease record in this trial. By April, 2008, all the varieties under testing had been attacked by CSPWD to varying degrees. The most susceptible varieties were WAT: Ex-Benin and Indian Laccadive Tall (LCT), with Catigan Green Dwarf (CATD) and Tacunan Green Dwarf (TACD) showing relatively high level of resistance. Interestingly, 3 SGD, 5 each of *Veitchia sp*, *Phoenix sp* and Oil palm, which are remnants from the previous trial, were still free of CSPWD as at March, 2008.

Table 3. Disease incidence in the 1981/83 resistance trials.

N°	Variety	Disease Level (%)					All Plots		Resistance Rating
		Ag.Jn.	Akwi.	Axim	Dixc	C3Pts	TL	CuDs (%)	
1	WAT	98	82	100	100	100	155	96	HS
2	MYD	71	31	-	0	100	51	51	LS
3	MRD	11	0	0	57	100	45	34	LR
4	CRD	50	23	-	50	80	46	51	LS
5	EGD	72	0	33	29	100	42	47	LR
6	SGD	0	0	1	0	0	59	0.2	HR
7	MYDxWAT	96	100	100	100	100	83	99	HS
8	MRDxWAT	86	63	100	60	100	72	82	LS
9	CRDxWAT	67	96	100	86	100	75	90	HS
10	EGDxWAT	64	-	100	83	100	34	87	HS
11	RNTxWAT	83	95	90	100	100	89	94	HS
12	SGDxWAT	86	100	-	-	100	63	95	HS
13	MYDxRNT	0	-	100	100	-	13	67	LS
14	CRDxRNT	0	-	100	100	-	19	67	LS
15	MYDxPYT	33	-	100	100	-	13	78	LS
16	CRDxPYT	50	-	25	89	-	21	55	LS
17	MRDxPYT	41	40	71	33	100	67	57	LS
18	CRDxVTT	86	-	100	89	-	19	92	HS
19	EGDxVTT	67	-	83	89	-	24	80	LS
20	MYDxVTT	44	-	100	25	-	22	56	LS
21	VTTxMLT	83	-	83	63	-	20	76	LS
22	CRDxMLT	64	44	57	71	100	58	67	LS
23	MYDxMLT	60	-	100	18	-	23	59	LS
24	MLT	43	-	75	100	-	17	73	LS
25	RNT	56	-	88	100	-	20	81	LS
26	PYT	67	-	0	86	-	11	51	LS
27	VTT	0	-	100	13	-	21	38	LR

TL: Total number of palms tested from all the trials. CuDs (%): Cumulated Disease level %
Resistance Rating (after scheme of Been, 1981):HR: highly resistant, disease level of less than 15 %. LR: less resistant, disease level 15-50%.LS: less susceptible, disease level 16-85%. HS: highly susceptible, disease level above 85%.

Table 4. Cumulated disease incidence in the 1995 planting (as at April 2008).

	Variety	Nº Observed	Nº Affected	Disease (%)	Resist. Rating
1	Indian Laccadive Tall (LCT)	49	43	87.8	HS
2	Indian Andaman Tall (ADOT)	43	31	72.1	LS
3	Panama Tall Monagre (PNT-02)	35	12	34.3	LR
4	Tagnanan Tall (TAGT)	32	7	21.9	LR
5	WAT Benin Type(WAT:EX-Benin)	56	52	92.9	HS
6	Catigan green Dwarf (CATD)	9	2	22.2	LR
7	Tacunan Green Dwarf (TACD)	10	1	10.0	HR
8	Panama Tall (PNT-01)	45	22	48.9	LR
	Total	**279**	**170**	**60.9**	

1.5. The 2007 Trials

Under the (FSP) Project, funded by the French Government, 8 varieties were introduced from Cote d'Ivoire in 2006. The new introductions comprised: MGD, Polynesian Red Dwarf, Indonesian Brown Dwarf, Niu Leka Dwarf, New Guinea Brown Dwarf, Thailand Green Dwarf, Cambodia Green Dwarf, and New Guinea Green Dwarf. These together with SGDxVTT and the local WAT varieties, have been planted for resistance screening at Asebu (Central Region), Nkroful (Western Region) and at the old trial plot at Cape 3 Points (Western Region) in 2007. All 3 trial locations are active disease foci, and a computer generated completely randomized design was used to ensure uniform exposure of all varieties to infection, however, there is no CSPWD incidence as yet.

1.6. The Rehabilitation Plantings

SGDxVTT: The high CSPWD resistance shown by the SGD and VTT varieties in the Dixcove trial (1981/83) led to the development of the SGDxVTT hybrid, which has been under screening at the Agona Junction plot since 1995. The hybrid was continuously exposed to CSPWD attack for 7 years, but after that, the disease became dormant in the plot. No incidence of CSPWD has occurred in this hybrid as yet, however, a 'genetic modeling analysis' has designated it as a 'promising hybrid' because of its predicted low susceptibility to CSPWD (Dery *et al*, 2008).

MYDxVTT: As mentioned in the Introduction, MYDxVTT was utilized in a rehabilitation programme to prevent the total collapse of the coconut industry. The programme involved 2 activities, an initial adaptive trial, conducted by OPRI-Coconut Programme, to 'field-test' the resistance-performance of the hybrid and a later more extensive re-planting under the Coconut Sector Development Project (CSDP), of the Ministry of Food and Agriculture, with funding from Agence Francaise de Developpement (AFD). For the adaptive trials, 33 farmers within active CSPWD zones were assisted to plant 120 seedlings each, which were routinely monitored by scientists for a period of 8 years. Of the 33 farmers, 14 abandoned their farms and final assessment of the performance of the hybrid was based on the records of 19 participant-farms. In these plots mortality due to CSPWD was estimated as 1% (Dery *et al.*, 2005), lending support to the decision to use the hybrid to revitalize the devastated coconut industry. Table 5 summarizes the results of the CSDP-MYDxVTT replantings. CSPWD has been confirmed in 62 ha, representing 4.8% of the total land cropped with the hybrid. Also 5.6% of the total number of farms of the replanting programme had been attacked by the disease. However, only 0.002% of the actual number of 'trees' originally planted had been affected. An exceptional case where CSPWD had killed 82% of the palms was encountered at Elmina in KEEA district.

Table 5. Incidence of CSPWD in MYD x VTT 'CSDP- Replantings' (May 2007)

Location		**Farms / Plots**			**HA**			**Palms**		
Reg	Distr	Pltd	Dis.	%	Pltd	Dis	%	Pltd	Dis	%
WR	Ahanta West	211	4	1.9	290	5	2.1	46400	7	0.0002
	Nzema East	303	10	3.3	397	16	4	63520	30	0.0005
	SAEMA	131	11	8.4	157	15	9.6	25120	30	0.001
	Wassa West	81	0	0	95	0	0	15200	0	0

CR	AAK	78	18	23.1	106	19	18.9	16960	140	0.01
	KEEA	221	7	3.2	255	7	2.8	40800	145	0.004
Total		1025	50	5.6	1300	62	4.8	208000	352	0.002

Reg: Region; Distr: District; Pltd: Total planted; Dis: Disease (CSPWD) level; %: Level of disease in percentage.

2. Discussion.

2.1. Malayan Dwarfs

The 3 'colour forms' of Malayan Dwarfs, reported to be resistant to LY, were successfully used for a replanting programme in Jamaica (Harries, 1995). Progenies of these varieties from LY-resistant mother palms that were screened in Ghana, all succumbed to CSPWD at Dzelukope (1966/69) and Cape 3 Points (1977). However, in the 1981/83 plantings, MRD showed varied resistance levels at the different trial locations (Table 3). A genetic modelling analysis of the results of the 1981/1983 trials, determined MRD as one of the most resistant varieties so far (Dery *et al.*, 2008). The obvious question that arises is whether the highly susceptible and highly resistant MRD encountered in these trials are genetically identical?

2.2. WAT: Ex-Benin.

Benin, a LY-free country, is sandwiched between Awka disease of Nigeria and Kaincope disease of Togo. It was therefore speculated that the coconut germplasm of Benin exhibited resistance against the disease. At Cape 3 Points the WAT: Ex-Benin proved to be highly susceptible to CSPWD (Table 4), thus disproving the earlier assumption.

2.3. Prospects for re-habilitating the coconut industry

Through a genetic modeling analysis, losses due to CSPWD was predicted to be about 64% in MYDxVTT plantings, but under the same conditions only 37% losses will be expected in the SGDxVTT (Dery *et al.*, 2008). The genetic modeling was found to show very good agreement between predicted and observed values, and lends credence to the earlier assumption that the SGDxVTT should be a better alternative to MYDxVTT to replant devastated areas. The SGDxVTT hybrid is under screening at Agona Junction. From preliminary observations, the hybrid 'promises' to show acceptable agronomic features (Dollet *et al*, 2006), but its 'field resistance' to CSPWD is yet to be tested, due to the absence of the disease in the plot since 2003. There are now 2 SGD seed gardens of 10 ha at Bonsaso and 5 ha at Kade, from which an SGDxVTT planting capacity of 200-300 ha per year is achievable (Dollet *et al*., 2006).

The VTT parent occurs in subpopulations, as evidenced by distinct variation in fruit characteristics and colour. It is important to determine if all the 'colour-forms' are equally resistant to CSPWD. To resolve this, each of the different 'colour-forms' of the VTT has been crossed with SGD, and the progenies planted in a 'randomised complete block design' to test their performance. There are also experiments to separate the VTT into 'pure lines' of its sub-populations, through 'diallel-crosses', which could then be tested for their resistance.

Dery *et al* (2008) suggested that the abnormal phenotypes of the SGD and VTT cultivars that succumbed to CSPWD at Axim, and the single VTT that was killed by CSPWD after it was scorched by fire at Dixcove, were due to some physiological malfunctioning or stress that could have compromised the inherent mechanism that conferred disease resistance to those ecotypes in the other trials. Ashburner and Been (1995) identified significant genotypic and environmental effects on the expression of resistance. Addison (1980) and Harries (1995) shared the view that the environmental conditions at the Dzelukope area could have made the Malayan Dwarf tested there exceptionally susceptible to the disease. Harries (1995) also lamented that soils with good drainage and fertility were reserved for high value crops and coconuts get relegated to poor soils in drought-prone areas where they survive but do not thrive. Under such conditions it appears LY is able to overcome resistance. Harries suggested that "if we could stop planting coconuts in suboptimal areas, we would perhaps make a positive step to controlling LY"; and

believed that large scale planting of resistant material should be undertaken only where growing conditions are good. The exceptionally high CSPWD incidence of 82% in a MYDxVTT replanting was attributed to unfavourable environmental conditions (Dollet, 2006; Dery *et al*., 2008). To succeed in the fight against CSPWD, therefore, it seems logical that an integrated approach comprising resistant coconut varieties planted in suitable areas and with good cultural practices should be adopted.

2.4. New Replantings

Dery *et al*, 2008 recommended that due to the high performance of MYDxVTT exhibited in most places, it should not be abandoned, but be used to crop areas far removed from disease zones, where risk of CSPWD is minimal. In the endemic zones it was recommended that only areas where the disease had 'passed' and the disease pressure was very low, could be cropped with SGDxVTT hybrid. Zones with active disease foci must not be planted with coconut. It must be ensured that good soil conditions and as well as good agronomic practices prevail to ensure good growth of the palm. Effective phytosanitation should ensure prompt elimination of any infected palm, so as to check disease spread.

2.5. Resistance Screening

It is common knowledge that disease resistance is not a 'once-forever' feature, it is therefore necessary that resistance screening in the country be continued. Dery *et al.,* (2008) observed that cultivars from the Pacific group, especially the dwarfs, were less susceptible than the Indo-Atlantic cultivars. Consequently, they recommended the introduction of more cultivars, especially Talls from the Pacific area (South-East Asia) for testing. Additionally, due to the appreciable performance of SGD in Ghana (Table 3), it should be worthwhile to test varieties that are genetically similar to the SGD. Dery *et al*, (2008) identified SGD and MRD as the most resistant varieties so far. It should be interesting to test the performance of the SGDxMRD hybrid against the CSPWD.

It will be important to employ the micro-satellite technique to confirm the identity of test palms, so as to determine 'off-types' that could otherwise confuse and frustrate screening results, as could have happened in the Axim trial.

Acknowledgement

The resistance trials have been funded at different times by the Ghana Government, French Embassy (Accra), the EU (EC STD3 Project), the World Bank under the National Agricultural Research Project (NARP) and the Agricultural Services Sub-Sector Investment Project AgSSIP), and the Agence Francaise de Developpement (AFD). We acknowledge their support. We also wish to thank Mr. K. A. Yawson and the technical and field staff of the OPRI-Coconut Programme for their assistance with the data collection.

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Photos 1: Growth habits of 25 year old SGD palms at Axim and Agona Jnc. plots

Abnormal palm at Axim:
Stunted and vegetative only.

Normal palm at Agona Jnc:
Luxurious and good nut load.

Photos 2. Growth habits of 25 year old VTT palms at Axim and Agona Jnc. Plots.

Abnormal palm at Axim:
Stunted and vegetative only.

Normal palm at Agona Jnc:
Luxurious and good nut load.