Vegetalika. 2019. 8(2): 125-138

Nutgrass Response to Drought Stress on Different Soil Types

Tanggapan Teki terhadap Cekaman Kekeringan pada Berbagai Jenis Tanah

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ABSTRACT

Nutgrass (*Cyperus rotundus*) is one of dominant weeds that can be grow in cultivated fields and able to grow on different soil types, even in limited water soil condition. This research aims to know the nutgrass growth and response to drought stress on different soil types. This experiment is pot experiment and was carried out in the greenhouse, Faculty of Agriculture, University of PGRI Yogyakarta, Kasihan, Bantul, Yogyakarta. The research was using factorial experiment 4 x 4 and were arranged in completely randomize design (CRD) with 3 times. The first factor were soil types, which consisted of four types i.e. coastal sands, alluvial, volcanic and grumusol. The second factor were drought stress, which consisted of four levels i.e. 25%, 50%, 75% and 100% field capacity. The observations were weed high, root length, tubers number, leaf width, specific leaf weight, shoots roots ratio, proline content and dry weight of weed. The data were analyzed used analysis of variance (ANOVA) at 5% significant levels. In measuring the difference among treatments were analyzed used Duncan's new multiple range test (DMRT) at 5% significant levels. The results of the research showed that nutgrass growth in the grumusol soil has higher weed, longer root, and higher dry weight of weed. However, greater tubers number, higher shoots roots ratio and proline content were found on the coastal sands soil. Wider leaf area was found on the coastal sands and grumosol soil. The thickest leaf was found on the volcanic soil. Nutgrass response on the 25% field capacity was showed that shoter weed high and root length, narrower leaf area, fewer tubers number, lower dry weight of weed and higher proline content. There was significant interaction between soil types and drought stress on the proline content.

Keywords: nutgrass weed; drought stress; soil types

INTISARI

Teki (Cyperus rotundus) merupakan salah satu gulma dominan yang dapat tumbuh pada berbagai lahan pertanian dan berbagai jenis tanah pada kondisi air yang terbatas. Penelitian ini bertujuan untuk mengetahui pertumbuhan dan tanggapan teki terhadap cekaman kekeringan pada berbagai jenis tanah. Penelitian ini menggunakan percobaan pot yang disusun dalam rancangan tersarang dan diulang tiga kali. Faktor pertama yaitu jenis tanah yang terdiri atas 4 jenis yaitu tanah pasir pantai, alluvial, vulkanik dan grumusol. Faktor kedua yaitu cekaman kekeringan yang terdiri atas empat aras yaitu 25%, 50%, 75% dan 100% kapasitas lapang. Pengamatan meliputi tinggi gulma, panjang akar, jumlah umbi, luas daun, berat daun khas, rasio tajuk akar, kandungan prolin dan bobot kering gulma. Data hasil pengamatan dianalisis dengan analisis varian pada jenjang nyata 5%. Perbedaan *antara perlakuan dianalisis dengan uji jarak berganda Duncan pada jenjang nyata 5%. Hasil penelitian menunjukkan pertumbuhan teki pada tanah grumusol memiliki tinggi lebih tinggi, akar lebih panjang, berat kering gulma lebih berat. Namun, teki yang tumbuh pada tanah pasir pantai memiliki jumlah umbi lebih banyak, daun lebih luas, rasio tajuk akar dan kandungan prolin lebih tinggi. Daun teki terluas ditemukan pada teki yang tumbuh pada tanah pasir pantai dan grumusol. Daun tertebal ditemukan pada tanah vulkanik. Teki yang tumbuh pada tanah dengan kadar air 25% kapasitas lapang mennujukkan tinggi dan panjang akar lebih pendek, daun lebih sempit, jumlah umbi lebih sedikit, bobot kering lebih rendah dan kandungan prolin lebih tinggi. Terjadi interaksi nyata antara jenis tanah dan cekaman kekeringan pada parameter kandungan prolin daun.*

Kata kunci: gulma teki; cekaman kekeringan; jenis tanah

INTRODUCTION

Nutgrass (*Cyperus rotundus*), also known as purple nutsedge, called “teki” in Indonesia. Nutgrass is a perennial weed that can growth dominantly on various cultivated plants. Nutgrass has characteristics that are very voracious on its growth factors, competitive, and invasive. The nutgrass organs consists of stems, leaf, roots, tubers, flowers, and seeds.

Nutgrass reproduces primarily by small underground tubers called nutlets that was formed at the end of underground stems called rhizomes (Patton and Weinsenberger, 2013). Each tuber is capable of producing a new weed and large networks of inter-connected tubers develop. In an ideal growing condition, a single tuber can produce 100 tubers in 90 days and about 90% of the tubers were found at 0-15 cm depth (Anonymous, 2014).

Weed consumes large quantities of water, which is largely evaporated into the air. The water which is used by different weed species were varied between 330-1900 liters to produce 1 kg of dry weight of weed. Weeds need nearly 2 times more water than it is needed by crops (Anderson, 1977). Water use efficiency (WUE) for weed type of C_4 is bigger, so it can absorb more water than C_3 type (Niu *et al*., 2005).

Drought is a condition where the soil water content is at limited condition for crop’s growth and production (Purwanto and Agustono, 2010). Water deficiency will disrupt the physiological or morphological activity that can cause growth inhibition. A continous water deficiency will cause the permanent wilting point and death (Santosa, 2008). Drought is one of abiotic factors that affects the growth and development of weed. Drought condition can cause growth failure. But weeds have a specific mechanism to adapt in osmotic potential in respond to drought stress. Drought causes morphological and physiological changes in weed organs that brings into the growth stunting. The weed’s root is the closest organ connected to the limited soil moisture, but the weed’s leaf gets the earliest effect (Kristanto *et al*., 2015).

Water have important role in growth and development of weed, because almost all physiological processes are affected by water. Water is required by weeds to maintain the turgidity of cells in physiological process on the enzyme activity. Nutgrass is a type of weed that can adapt at drought condition. Water has significant impact on the nutrient absorption done by the root. A continous water deficiency can cause the growth stunting and even death. However, in fact, nutgrass can survive and adapt well in the environment, even in drought. Weeds tissue consist 70-80% of water.

The weed response to drought stress is initiated by the physiological response, which is a series of processes inside its organ. It is followed by morphological change as weeds defense mechanism in respond to drought stress. The morphological change will affect the physiological process, so they basically affect on each other. Those changes are shown in weeds growth.

The effect of drought on vegetative phase can reduce the rate of leaf enlargement and the wide index of leaf on the next growth phase. High level of drought can cause closure of stomatal, that reduce the uptake of carbon dioxide and the decrease of biomass production (Gardner *et al*., 1991). According to Salisbury and Ross (1992), during the drought, some stomatas will close and cause the decrease of CO_2 intake that is followed by the decrease of photosynthetic activity, inhibit of protein synthetic and cell wall.

The physiological change can be in the form of accumulation of organic compatible compounds functioning to maintain the osmolit balance in the plant organ. One of organic compatible compounds which is accumulated by plant during drought called proline. According to Yasemin (2005), during drought, there will be a decreasing rate of photosynthesis process was caused by stomatal closure and a decrease of the electrons transport and fosforilation capacity in leaf chloroplast.

Nutgrass can be found in cultivated fields, farmlands, neglected areas, wastelands, grasslands, at the edges of forests, and on roadsides, sandy or gravelly shores, riverbanks and irrigation canal banks, agricultural areas, coastland, water course. Nutgrass grows well in almost every soil type, over a wide range of soil moisture, pH and elevation. It is encouraged by frequent cultivation and grown best in moist fertile soil (Nalini *et al*., 2014). Nutgrass is one of weeds which can grow and adapt well in various types of soil. Nutgrass can use water efficiently to complete its live cycle. According to Yuwono (2009), the characteristics of coastal sands soil were sandy, crumb, lower nutrient content, lower water binding capacity, high soil temperature at the afternoon, high wind speed and rate of evaporation.

Soil texture was not only affects the amount of water that can be stored in a soil within the root zone. Typically, sandy soil has lower water holding capacity and greater aeration, whereas, clay soil has higher water holding capacity and less aeration. Soil texture also affects fertility of the soil. Sandy soil has a lower capacity to hold cations and a low cation exchange capacity (CEC). Clay particles have high CEC, generally more fertile and can hold more water. Soil texture also affects the amount of oxygen available for root growth (Stichler, 2002). Sandy soil are characterized by less than 18% clay and more than 68% sands in the first 100 cm of the solum. Sandy soil are often considered as soil with physical properties that easy to define weak structure or no structure, poor water retention properties, high permeability, and highly sensitivity to compaction with many adverse consequences (Bruand *et al*., 2005).

Soil morphology of inceptisol (alluvial) are showed solum shallow, dominated by clay texture, color range varies from yellowish gray to dark brown, angular blocky structure with average development level, and hard consistency when dry (Ulfiyah *et al*., 2014). The characteristics of alluvial soil are pH soil < 6, clay, hard when dry, sands < 50%, absorbs water easy, soil colour brown, and relatively high nutrient content. Volcanic soil has high nutrient content, lush, fine-grained and low volume weight. The grumusol soil is soil type that is less fertile, organic mater < 45%, clays, high absorp water, color gray to black, and pH soil netral to alkalis.

MATERIALS AND METHODS

This research was aimed to know the nutgrass growth and response to drought stress on different soil types. This research was carried out in a greenhouse facility, Faculty of Agriculture, University of PGRI Yogyakarta, May to July 2018.

This research was a pot experiment arranged in nested design and repeated three times. The first factor was soil types, which consisted of four types; coastal sands, alluvial, volcanic and grumusol. The second factor was drought stress treatment, which consisted of four levels; 25%, 50%, 75% and 100% field capacity.

The soil used for the experiment is determined in terms of its soil capacity. The determination of the soil capacity was done by gravimetric method. Soil capacity can be tested by sprinkling water in the media until it is saturated and stop dripping out of polybag (Santosa, 2008).

The soil used for the experiment was taken from the top-soil layer. Before being put into each polybag, the soil was dried under the sunligt. After that, the soil was mashed into small same size and free from tubers of nutgrass. The soil was weighed before being put into each polybag. Every polybag was filled the same weigh of 6 kgs soil. Then, the soil was put into polybags of the size of 30 x 30 cm and 20 cm of diameters.

The tubers of nutgrass were prepared in same size. Before tubers were planted, the soil in polybag was watered up to field capacity. Then, five tubers of nutgrass were planted. The next day, shoots of nutgrass grew in each polybag. Nutgrass was kept until the age of 40 days after planting (DAP). If there were other types of weeds which grew in the polybags in the soil surface would be removed.

The drought stress of 25%; 50%; 75% and 100% field capacity with gravimetric method on each soil types were done as follows:

1. Coastal sands soil :
   a). 25% field capacity = 6 kg soil + 326 g water,
   b). 50% field capacity = 6 kg soil + 653 g water,
   c). 75% field capacity = 6 kg soil + 979 g water,
   d). 100% field capacity = 6 kg soil + 1,305 g water.
2. Alluvial soil:
   a). 25% field capacity = 6 kg soil + 446 g water,
   b). 50% field capacity = 6 kg soil + 893 g water,
   c). 75% field capacity = 6 kg soil + 1,339 g water,
   d). 100% field capacity = 6 kg soil + 1,785 g water.
3. Volcanic soil :
   a). 25% field capacity = 6 kg soil + 253 g water,
   b). 50% field capacity = 6 kg soil + 505 g water,
   c). 75% field capacity = 6 kg soil + 758 g water,
   d). 100% field capacity = 6 kg soil + 1,010 g water.

4. Grumusol soil :
   a). 25% field capacity = 6 kg soil + 455 g water,
   b). 50% field capacity = 6 kg soil + 910 g water,
   c). 75% field capacity = 6 kg soil + 1,365 g water,
   d). 100% field capacity = 6 kg soil + 1,820 g water.

The treatments were started at the age of 10 DAP. In mantaining the soil water content from field capacity at each treatment, then measuring the weigh of polybags were done one by one at 16.00 o'clock every two days. Water management on field capacity were terminated at the age of 40 DAP (end of research).

The weed growth were observed at age of 40 DAP. The observations include weed high, roots length, tubers number, leaf width, specific leaf weight, thickness of leaf, shoots roots ratio, proline content and dry weight of weed.

The data was analyzed by analysis of variance at 5% significant levels. To figure out the difference among the treatments, Duncan's new multiple range test (DMRT) was used at 5% significant levels (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Based on analysis of variance show that there were not signinificant interaction between soil types and drought stress on weed high (Apendix 1). Soil types had significant effect on the weed high. Drought stress had significant effect on weed high (Table 1).

There is difference in nutgrass high in four types of soil. Nutgrass can grow well in barren soil especially on fertile soil. Nutgrass grew in the gurumusol and alluvial higher than in coastal sands and volcanic. Grumusol and alluvial have hight nutrient than coastal sands and volcanic.

Drought stress caused a decrease in growth of nutgrass high. On the soil of 25% ield capacity, nutgrass were shorter in the coastal sands, so increase in 50% field capacity. In low field capacity, nutgrass growth will be inhibited. Nutgrass grew higher in 75% and 100 fielld capacity, because enough water for growth.

Table 1. The average of weed high (cm)

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	12,57	14,20	9,75	12,99	12,38 r
50	14,97	16,27	11,84	17,35	15,11 q
75	16,80	17,52	13,32	21,32	17,24 p
100	18,30	18,64	15,36	21,30	18,40 p
Average	15,66 b	16,66 b	12,57 c	18,24 a	(-)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 9.70% and (-) = No interaction.

Based on analysis of variance show that there were not signinificant interaction between soil types and drought stress on root lenght (Apendix 1). Soil types had significant effect on root length. Drought stress had significant effect on root length (Table 2).

The longest root was found on the grumusol soil and different from the other soil types. There is no difference in the length of the root in coastal sands, alluvial and volcanic soil. Grumusol soils had a high water absorbtion so that it was always moisture and easily penetrated by the root. The coastal sands and volcanic could not hold water for a long time, as well as the alluvial soil that was solid quickly when water shortages. Such conditions interfered the roots growth. Soil texture affects the amount of oxygen available for root growth in aeration.

There were different significant between treatment of fied capacity. At the 25% field capacity caused shoter root length than others treatment. The water limitations in the soil caused inhibite the growth of nutgrass root. Increasing of the field capacity caused longer root length of nutgrass. At the 100% field capacity caused longest root. The enough water in the soil will affect root growth better.

Table 2. The average of root lenght (cm)

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	24,00	27,73	25,98	32,20	27,48 s
50	28,92	30,30	29,65	34,18	30,76 r
75	29,87	31,00	32,60	39,33	33,20 q
100	33,13	33,87	34,07	42,62	35,92 p
Average	28,98 b	30,73 b	30,58 b	37,08 a	(-)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 7.89% and (-) = No interaction.

Based on analysis of variance show that there were not signinificant interaction between soil types and drought stress on tubers number (Apendix 1). Soil types had significant effect on the tubers number. Drought stress had significant effect on the tubers number (Table 3).

The largest tuber number formed on the coastal sands soil, then descending on the grumusol and lower on the soil of volcanic and alluvial. The large tubers number formed on the coastal sands soil was affected by the crumbs forms of the soil structure. The rhizome from the nutgrass tuber could grow easily. The soil of alluvial and grumusol structure were compressible so that the rhizome growth was inhibited in the soil.

At the soil water content of 25% field capacity caused a significant decrease of the tubers number. The tubers number that formed at the 25% field capacity causing the water available became minimum. Water was needed by weed in photosynthesis process. Water deficiency will inhibited the physiological activity of nutgrass especially photosynthesis process. This condition caused carbohydrat produced to be lower so that formed the tubers number could not be maximized.

Photosynthesis is the process in which the leaf take in carbon dioxide from the air through tiny openings and chlorophyll in the leaf captures the light energy from the sun, splits carbon dioxide and water and recombines the carbon into carbohydrates. Leaf area affect on captures energy from the sun and converts the energy into carbohydrates, which it eventually uses, along with nutgrass nutrients and minerals for cell division or growth, development and reproduction (Stichler, 2002).

Table 3. The average of tubers number

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	18,33	11,67	9,67	13,67	13,33 r
50	22,33	12,00	11,00	16,33	15,42 q
75	23,67	12,00	10,33	19,33	16,33 pq
100	24,00	14,00	11,67	19,67	17,33 p
Average	22,08 a	12,42 c	10,67 c	17,25 b	(-)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 12.88% and (-) = No interaction.

Based on analysis of variance show that there were not signinificant interaction between soil types and drought stress on leaf area (Apendix 1). Soil types had significant effect on the leaf area. Drought stress had significant effect on leaf area (Table 4).

The widest leaf was found on the nutgrass which grew on the coastal sands and grumusol. It was significant different from those grew in the volcanic and alluvial. The internodus distance of the nutgrass leaf that grew on coastal sands soil were taller on the stem, while leaf were wider on the volcanic, alluvial, and grumusol. But wider leaf area of weed on the grumusol was caused by weed habitus was higher and a lot of leaf number.

At the soil water content of 25% field capacity caused more leaf area got narrower. On the soil water content in minimum conditions, nutgrass formed the size of smaller leaf than nutgrass which grew at normal conditions. It aimed at reducing the rate of transpiration from the leaf.

Table 4. The average of leaf area (cm^2)

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	1.578,4	763,4	645,4	1.425,6	1.103,2 r
50	1.861,9	880,9	760,9	1.815,3	1.329,7 q
75	2.100,4	1.013,9	886,4	2.153,9	1.538,6 p
100	2,192,2	1.027,4	976,1	2.258,4	1.613,5 p
Average	1.933,2 a	921,43 b	817,2 b	1.913,3 a	(-)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 10.09% and (-) = No interaction.

Based on analysis of variance show that there were not signinificant interaction between soil types and drought stress on specific leaf weight (Apendix 1). Soil types had significant effect on specific leaf weight. Drought stress had not significant effect on specific leaf weight (Table 5).

Specific leaf weight is the weight of leaf per unit of leaf area illustrating leaf thickness ($g\ cm^{-2}$). Nutgrass which grew on the volcanic soil had thicker leaf than those in the coastal sands or soil grumusol. There was not significant difference between the thickness leaf on the alluvial soil. Nutgrass which grew in coastal sands and grumusol soil had thinner leaf. On the grumusol soil, the nutgrass grew better. There were over shading between their leaf that caused the thinner leaf.

Table 5. The average of specific leaf weight ($g\ cm^{-2}$)

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	0,0039	0,0043	0,0051	0,0041	0,0043 p
50	0,0042	0,0048	0,0043	0,0035	0,0042 p
75	0,0041	0,0045	0,0046	0,0039	0,0043 p
100	0,0042	0,0046	0,0051	0,0041	0,0045 p
Average	0,0041 b	0,0045 ab	0,0048 a	0,0039 b	(-)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 15.63% and (-) = No interaction.

Based on analysis of variance show that there were not signinificant interaction between soil types and drought stress on shoot root ratio (Apendix 1). Soil types had significant effect on shoots roots ratio. Drought stress had not significant effect on shoots root ratio (Table 6).

Nutgrass which grew on the coastal sands soil has highest shoots roots ratio, descending on the grumusol, volcanic and the lowest in alluvial soils. Nutgrass in the coastal sands soil were stronger at the shoots than roots. The shoots growth on coastal sands was stonger than others soil types. Unlike the nutgrass which grew on alluvial soil showed that shoots growth lower than the others soil types. Nutgrass which grew on alluvial soils had strengthen the roots growth.

Table 6. The average of shoots root ratio

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	0,923	0,302	0,487	0,692	0,601 p
50	1,078	0,350	0,392	0,584	0,601 p
75	1,082	0,345	0,442	0,648	0,629 p
100	1,009	0,338	0,470	0,792	0,652 p
Average	1,023 a	0,334 d	0,448 c	0,679 b	(-)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 14.84% and (-) = No interaction.

Based on analysis of variance show that there were signinificant interaction between soil types and drought stress on proline content (Apendix 1). Interaction between soil types and drought stress on proline content could be seen in Table 7.

The highest proline accumulation found in the growth of nutgrass on the coastal sands in field capacity of 25%, 50%, 75% and 100%, and on the volcanic soil in the field capacity of 25% and 50%. Then descending on the alluvial soils in field capacity of 25% and 50%. The lowest proline content on the alluvial and volcanic soil in field capacity of 75% and 100%, and in the grumusol in field capacity of 25%, 50%, 75% and 100%.

The evaporation rate on the coastal sands in all field capacity or on the volcanic soil in the low field capacity were larger than on the alluvial and grumusol soil, that caused the nutgrass leaf was quickly permanent wilting point. Sandy soil was easily evaporates water because it has porous soil properties. A high proline accumulation in coastal sands and volcanic soil were caused faster evaporation rate from the soil surface.

Table 7. The average of proline content (µ mol proline g^{-1} leaf)

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	40,45 a	16,48 b	29,03 a	2,80 c	22,19
50	34,71 a	9,32 bc	28,45 a	1,42 c	18,48
75	31,38 a	0,16 c	3,89 c	0,68 c	9,03
100	29,03 a	0,12 c	3,46 c	0,05 c	8,17
Average	33,89	6,52	16,21	1,24	(+)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 23.28% and (+) = Significant interaction.

Based on analysis of variance show that there were not signinificant interaction between soil types and drought stress on dry weight of weed (Apendix 1). Soil types had significant effect on dry weight of weed. Drought stress had significant effect on dry weight of weed (Table 8).

Grumusol supported the growth of dry weight of weed better than volcanic soil, but there was significant difference on the alluvial, coastal sands and volcanic. Grumusol was a soil of clays that had high water binding ability so that the constructor could grow well. Grumusol soils had a high CEC and were generally more fertile and absorbed more water. Coastal sands soils had a lower capacity to hold cations, and had a low CEC, and cation exchange capacity.

At the soil water content of 25% field capacity inhibited the growth of dry weight of weed. The low of soil water availability inhibited the root activity of nutgrass so that the process of nutrient absorption in being disturbed. The process of transport nutrient from the soil to the leaf was disturbed. Likewise on the soil water content is low, then the weeds would close the stomatal so that CO_2 into the leaf tissue becomes limited. A result of this incident, then the process of the formation of carbohydrates being reduced in the photosynthesis process.

Table 8. The average of dry weight of weed (g)

Drougth Stress (% field capacity)	Soil types				Average
	Coastal sands	Alluvial	Volcanic	Grumusol	
25	12,63	14,20	9,75	14,19	12,69 r
50	14,97	16,27	11,84	17,35	15,11 q
75	16,80	17,52	13,32	21,32	17,24 p
100	18,30	18,64	15,36	21,30	18,40 p
Average	15,68 b	16,66 b	12,57 c	18,54 a	(-)

Remarks: The average in row or column followed by the same characters are not significantly different based on DMRT at 5% levels. Coefficient variation (CV) = 9.81% and (-) = Interaction.

CONCLUSION

1. Nutgrass growth in the grumusol soil has higher weed, longer root, and higher dry weight of weed. However, greater tubers number, higher shoots roots ratio and proline content were found on the coastal sands soil. Wider leaf area was found on the coastal sands and grumosol soil. The thickest leaf was found on the volcanic soil.
2. Nutgrass response on the 25% field capacity was showed that shoter weed high and root length, narrower leaf area, fewer tubers number, lower dry weight of weed and higher proline content.
3. There was significant interaction between soil types and drought stress on the proline content.

ACKNOWLEDGEMENT

The researchers thanks to Mr. Suparno as laboran of the experiment garden Agroshop, Universitas PGRI Yogyakarta, who had provided the tools of this research .Thanks to Mr. Sukadi, Sudi Waluyo and Tendy as Agrotechnology students, Faculty of Agriculture, University of PGRI Yogyakarta in the experiment garden Agroshop who had helped in implementing the research. Thanks to Mr. Widodo, and Mr. Hasyim Marga who helped and gave support on the analysis of proline content in the laboratory of Agronomy UGM.

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Appendix 1. Analysis of variance (ANOVA) to all parameters were observed

Source of variation (SV)	Degree of Freedom (DF)	Mean square (MS)								F. table 5%
		Parameters								
		Weed high	Root lenght	Tuber number	Leaf Área	Specific leaf weight	Shoot root ratio	Proline content	Dry weight of weed	
Treament	15	32.35 *	73.34 *	64.43 *	1045117.5 *	5.468E-07 ns	0.2309 *	15.492 *	31.209 *	1.99
A	3	68.59 *	316.91 *	154.08 *	4465994.4 *	1.844E-06 *	1.1087 *	52.384 *	74.722 *	2.90
B	3	84.04 *	34.85 *	154.72 *	631178.5 *	1.936E-07 ns	0.0074 ns	18.076 *	75.811 *	2.90
A x B	9	3.04 ns	4.98 ns	4.45 ns	42804.8 ns	2.323E-07 ns	0.0129 ns	2.334 *	1.837 ns	2.19
Error	32	2.34	4.04	6.31	19834.7	4.573E-07	0.0085	0.503	2.423	

Remarks : A = Soil types, B = Drought stress, and A x B = Interaction between A and B.
 * = Significant, and ns = non significant.