Int.J.Curr.Microbiol.App.Sci (2018) *7*(9): 3184-3194

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 09 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.709.396

A Study Physical Properties and Functional Characteristics of Selected Horsegram [*Macrotyloma uniflorum* (Lam) Verdc.] Varieties

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Keywords

Horsegram (*Macrotyloma uniflorum* (Lam) Verdc.), Food legumes

Article Info

Accepted:
20 August 2018
Available Online:
10 September 2018

A B S T R A C T

Horsegram [*Macrotyloma uniflorum* (Lam) Verdc.] is minor legume, which belongs to family *Fabaceace*. It is a potential grain legume having excellent nutritional quality with better resilience property to adapt harsh environment conditions. Seven released varieties and five advanced breeding lines of horsegram were procured from All India Coordinated Research Project – Dryland Agriculture, Vijayapur. The horsegram were analyzed for physical properties *i.e.*, length, breadth, length to breadth, hundred kernel weight, hundred kernel volume and bulk density and functional properties *i.e.*, hydration capacity, hydration index, swelling capacity, swelling index and per cent germination. The physical properties and functional characteristics varied significantly among the varieties. The length ranged from 5.575-6.133 mm, breadth ranged from 3.558-4.132mm and length to breadth ratio ranged from 1.415-1.625 respectively. The bulk density ranged from 1.415 – 1.652 g/ml. The functional characteristics of horsegram varieties ranged viz., hydration capacity (0.024-0.036 g/grain), swelling capacity (0.020-0.040 ml/grain) varied significantly. The germination per cent was highest in DHG01 (94%) and lowest in VHG15 (71.33%).

Introduction

Food legumes constitute an important component of diet across the world and are the next important food crops after cereals. As a result, pulses have significant cultural and historical significance (Roy *et al.*, 2010). They play a vital role in sustainable agriculture and a key source of dietary nutrients for many of people in the developing countries. The legumes belongs to family Leguminosae (Fabaceace) which are eaten directly by humans, usually in the form of mature dry seeds, but sometimes in the form of immature seeds attached in the pod. Dehulled pulses, also known as *dals*, are famous for their high quality protein content and are considered as meat substitutes for people in less developed countries. Legumes are good sources of protein that are cheap and widely available for human consumption. They are staple foods for many people in different parts of the world. Legume seeds have an average of twice as much protein as cereals and nutritive value of the proteins are usually high. They are widely cultivated and distributed in Africa, Asia,

West Indies, Latin America and India. The legumes can be grown in marginal soils and in arid or semi-arid regions. Their deep penetrating root system enables them to withstand moisture stress (Bhokre and Joshi, 2015).

Among legumes, horsegram [*Macrotyloma uniflorum* (Lam.) Verdc.] is a minor legume crop of India and is of good nutritional quality (Pal *et al.,* 2015). It belongs to family *Fabaceace,* has potential nutritional and remedial properties with better climate resilience to adapt to harsh environmental conditions. It is one of the most important under exploited food legume being grown almost all over the world including temperate and sub-tropical regions encompassing the countries particularly, India, China, Philippines, Bhutan, Pakistan, Sri Lanka and Australia (Durga, 2016; Bhartiya *et al.,* 2015). In India it is most extensively grown pulse in the south, the maximum area being in Andhra Pradesh, Karnataka and Tamil Nadu. It is grown mainly to furnish feed and fodder for cattle and horse. It makes excellent hay and is suitable as green manure. Horsegram is however consumed as sprouts in many parts of India. Consumption of sprouted pulses is gaining importance in recent days as it serves as a good source for maintaining people's health and conscious with diet. The seeds and sprouts have high nutritional value and they lower the risk of many diseases and influence health promoting effects. The use of horsegram as human food is limited due to its poor cooking quality, presence of high levels of enzyme inhibitors and presence of high tannins and polyphenols. It is usually consumed as sprouts and cooked with spices before consumption and traditionally consumed as curry. Improvement and release of new varieties having superior agronomical features, resistance to insect and diseases and quality parameter is a continuous process. However, the acceptability of these varieties by consumers in the utilization should be assessed besides knowing the composition and cooking quality. Hence the present study is undertaken to assess physical properties and functional characteristics of horsegram varieties.

Materials and Methods

Procurement of the horsegram varieties

Twelve varieties of horsegram were procured from AICRP for Dryland Agriculture RARS, Vijayapur, Karnataka. Out of twelve varieties five were advanced breeding line of University of Agricultural Sciences, Dharwad, while remaining seven varieties were released for cultivation across different regions. The details regarding the samples are given in Table 1. The samples were cleaned before the study was carried out. All estimations were carried out in triplicates.

Physico-chemical properties of horsegram varieties

Physical properties of horsegram varieties

The various physical properties assessed were hundred kernel weight, hundred kernel volume, bulk density, length, breadth and length/breadth ratio (L/B ratio) by using standard methods. The methods employed are detailed below.

Hundred kernel weight

Weight of randomly selected hundred grains was recorded in grams using electronic weighing balance with the sensitivity of 0.01 mg (Khatun *et al.,* 2013). Mean weight was expressed in gram/100 grains.

Hundred kernel volume

The grain volume was measured using water displacement method in triplicate. Hundred randomly selected grains were added in

measuring cylinder containing known volume of water. The difference in the volume was recorded in ml (Bhokre *et al.,* 2015). Average volume was expressed as millilitre/100 grains.

Bulk density

Grain bulk density was calculated using the formula (Bhokre *et al., 2015)*

$$\text{Bulk density} = \frac{\text{Grain weight (g)}}{\text{Grain volume (ml)}}$$

Length, breadth and L/B ratio of horsegram varieties

The average length and breadth of the ten randomly selected horsegram grains were measured in millimetre with the help of digital vernier calliper least count 0.01 mm. The length/breadth ratio was obtained by dividing the length of a single grain by the corresponding breadth to determine the size and shape. (Jain *et al.,* 2012)

Functional properties

Germination per cent (%)

One hundred randomly selected seeds were soaked overnight and placed in a petriplate containing dampened filter paper. This petriplate containing seeds was placed in incubator for 24 hours and allowed to germinate.

After germination, germinated seeds were counted and percentage was calculated and expressed in per cent (%) (Khatun *et al.,* 2013).

Hydration capacity

Hydration capacity was measured by soaking weighed 100 seeds overnight in beaker with 100 ml of water. Next day, water was drained off and seeds were dried using filter paper and weighed (Khatum *et al.,* (2013) and Bhokre *et al.,* (2015)). Hydration capacity was calculated by:

$$\text{Hydration capacity of seeds} = \frac{\text{Weight after soaking (g)} - \text{Weight before soaking (g)}}{\text{Number of seeds}}$$

Hydration index

Hydration index is calculated by using formula:

$$\text{Hydration index} = \frac{\text{Hydration capacity}}{\text{Weight of seeds}}$$

Swelling capacity (ml/grain)

Hundred seeds were counted and volume was noted. Seeds were soaked overnight. Further, water was drained off next day and volume was noted (Bhokre *et al.,* 2015). Then, the swelling capacity was measured using formula:

$$\text{Swelling capacity} = \frac{\text{Volume of seeds after soaking (ml)} - \text{Volume of seeds before soaking (ml)}}{\text{Number of seeds}}$$

Swelling index

Swelling index is calculated using formula:

$$\text{Swelling index} = \frac{\text{Swelling capacity}}{\text{Volume of seeds}}$$

Statistical analysis

The experiment were carried out by following statistical methods

Mean, standard deviation was used to interpret data.

ANOVA (Analysis of variance) was used to know the significant difference among the varieties.

Independent t-test was used to know the significant difference between released varieties and advanced breeding line of horsegram varieties.

Results and Discussion

Physicochemical properties

Physical properties of horsegram varieties

The physical properties of horsegram varieties *i.e.* length, breadth, length/breadth, hundred kernel weight, hundred kernel volume and bulk density is presented in Table 2. The length, breadth, length/ breath ratio varied significantly ($p \leq 0.01$) among the varieties. The length of horsegram varieties ranged from 5.57-6.13 mm. The highest length was observed in DHG01 (6.13 mm) followed by VHG44 (6.60 mm) and VHG15 (6.02 mm) and least length was observed in CRHG22 (5.57 mm). The breadth ranged from 3.55-4.13mm. Highest breadth was noted in AK42 (4.13 mm) and lowest was noted in CRHG23 (3.55 mm). The length to breath ratio of horsegram varieties ranged from 1.41-1.65. Highest length to breadth ratio was observed in VHG15 (1.65) followed by VHG13-01 (1.62) and DHG01 (1.57) and lowest was noted in AK42 (1.41).). The study conducted by Bhokre *et al.,* (2015) showed similar values for length (5.3-6.1mm) and breadth (3.5-4.0 mm) of horsegram varieties.

Hundred kernel volume and bulk density of horsegram varieties varied significantly among the varieties, whereas hundred kernel weight was not significant among the varieties. The hundred kernel weight, hundred kernel volume and bulk density ranged 2.93-3.55 g, 2.00-2.50 ml and 1.17-1.64 g/ml respectively. Highest hundred kernel weight was recorded in AK44 (3.57 g) followed by DHG01 (3.54 g) and VHG938 (3.47 g) and lowest was recorded in VHG935 (2.93 g). In hundred kernel volume, highest volume *i.e.,* 2.50 ml was observed in AK42, AK44, DHG01, GPM06, VHG13-01, VHG15, VHG44, VHG935 and VHG398 followed by CRHG23 (2.16 ml) and lowest was observed in CRHG22 (2.00 ml). Highest bulk density was recorded in GPM06 (1.64 g/ml) and lowest was recorded in VHG935 (1.17). The study conducted by Bhokre *et al.,* (2015) showed slightly higher values for hundred kernel weight and hundred kernel volume. The reason for this variation in the present study may be due to varietal divergence.

Physical properties between released and advanced breeding lines of horsegram

Table 3 compares the physical properties between the released varieties and advanced breeding lines of horsegram varieties. Results revealed that there was no significant difference in length, breadth and hundred kernel weight while, Length to breadth ratio, hundred kernel volume and bulk density differed significantly ($p \leq 0.05$). Released varieties registered higher breadth, hundred kernel weight and bulk density compared to advanced breeding line of horsegram varieties, whereas advanced breeding lines had higher values of length, length to breadth ratio and hundred kernel volume.

Functional properties

Functional properties of horsegram varieties

The functional properties of horsegram varieties *i.e.,* hydration capacity, hydration

index, swelling capacity and swelling index are presented in Table 4. Significant differences ($p \leq 0.01$) were observed in hydration index, swelling capacity and swelling index. The hydration capacity and hydration index ranged from 0.024-0.035 g/grain and 0.007-0.010 respectively.

Highest hydration capacity was observed in DHG01 and the lowest was observed in KBHG01 and VHG13-01, higher hydration index was also observed in DHG01, GPM06 and VHG938, while lower noted in VHG13-01. Highest swelling capacity was observed in DHG01 (0.04 ml/grain) and lowest was observed in VHG13-01 (0.020 ml/grain). The swelling index ranged from 0.008-0.019. Highest was observed in GPM06 and lowest in VHG13-01. Study conducted by Jain *et al.,* (2012) showed slightly lower results for hydration capacity and swelling capacity. This may be due the variations in the physical parameters and geographical conditions in which they are grown.

Functional properties between released and advanced breeding lines of horsegram

Table 5 depicts the comparison of functional properties between released varieties and advanced breeding lines of horsegram varieties. There was no significant difference between hydration capacity and hydration index. Swelling capacity and swelling index differed significantly ($p \leq 0.01$). All the parameters *i.e.*, hydration capacity, hydration index, swelling capacity and swelling index were higher in released varieties compared to advanced breeding lines of horsegram varieties.

Table.1 Horsegram varieties selected for study

Horsegram varieties	
Released varieties	**Advanced breeding lines**
AK 42- ARJIA KULTHI 42	VHG 13-01- VIJAYAPUR HORSEGRAM -13-01
AK 44- ARJIA KULTHI 44	VHG 15- VIJAYAPUR HORSEGRAM -15
CRHG 22- CRIDA HORSEGRAM 22	VHG 44- VIJAYAPUR HORSEGRAM -44
CRHG 23- CRIDA HORSEGRAM 23	VHG 935- VIJAYAPUR HORSEGRAM -935
DHG 01- DANTEWADA HORSEGRAM 01	VHG 938-- VIJAYAPUR HORSEGRAM -938
GPM 06- GERMPLASM SELECTION 06	
KBHG 01- KARNATAKA BIJAPUR HORSEGRAM- 01	

Table.2 Physical properties of horsegram varieties

Varieties	Length (mm)	Breadth (mm)	L/B	100 kernel weight (g)	100 kernel volume (ml)	Bulk density (g/ml)
Released varieties						
AK42	5.84 ± 0.49 ^{abc}	4.12 ± 0.31^{a}	1.41 ± 0.15 ^{d}	3.29 ± 0.42 ^{abc}	2.50 ± 0.00^{a}	1.31 ± 0.01 ^{cde}
AK44	5.86 ± 0.31 ^{abc}	4.05 ± 0.29 ^{a}	1.44 ± 0.11 ^{cd}	3.35 ± 0.05^{ab}	2.50 ± 0.00 ^{a}	1.34 ± 0.02^{cde}
DHG01	6.13 ± 0.09^{a}	3.90 ± 0.25^{abc}	1.57 ± 0.11^{abc}	3.54 ± 0.05^{a}	2.50 ± 0.00 ^{a}	1.41 ± 0.02^{cd}
GPM06	5.78 ± 0.41^{bc}	4.03 ± 0.16 ^{a}	1.43 ± 0.13^{d}	3.28 ± 0.06 ^{abc}	2.50 ± 0.00^{c}	1.64 ± 0.03^{a}
KBHG01	5.90 ± 0.32^{abc}	3.94 ± 0.20 ^{ab}	1.49 ± 0.13 ^{cd}	3.31 ± 0.92^{abc}	2.50 ± 0.00 ^{a}	1.30 ± 0.07 ^{cde}
CRHG22	5.57 ± 0.33^{cd}	3.70 ± 0.23^{bcd}	1.50 ± 0.11^{cd}	3.11 ± 0.05^{bcd}	2.00 ± 0.00^{c}	1.53 ± 0.02^{ab}
CRHG23	5.58 ± 0.29^{d}	3.55 ± 0.27^{d}	1.51 ± 0.11^{bcd}	2.98 ± 0.03^{cd}	2.16 ± 0.28^{b}	1.39 ± 0.17^{bcd}
Advanced breeding lines						
VHG13-01	5.81 ± 0.37 ^{abc}	3.57 ± 0.22^{d}	1.62 ± 0.10^{bc}	3.06 ± 0.03 ^{abc}	2.50 ± 0.00 ^{a}	1.25 ± 0.04 ^{cde}
VHG15	6.02 ± 0.18^{ab}	3.65 ± 0.24^{cd}	1.65 ± 0.10^{a}	3.09 ± 0.03 ^{abc}	2.50 ± 0.00	1.23 ± 0.01^{de}
VHG44	6.06 ± 0.30^{ab}	3.94 ± 0.25 ^{ab}	1.54 ± 0.10^{abcd}	3.30 ± 0.60 ^{abc}	2.50 ± 0.00 ^{a}	1.32 ± 0.24 ^{cde}
VHG935	5.86 ± 0.21 ^{abc}	4.04 ± 0.55 ^{a}	1.49 ± 0.13 ^{cd}	2.93 ± 0.03^{d}	2.50 ± 0.00 ^{a}	1.17 ± 0.01^{e}
VHG938	5.81 ± 0.33 ^{abc}	3.94 ± 0.26 ^{ab}	1.47 ± 0.13 ^{cd}	3.47 ± 0.01^{a}	2.50 ± 0.00 ^{a}	1.39 ± 0.00^{bcd}
Mean ±SD	5.83 ± 0.36	3.87 ± 0.33	1.51 ± 0.13	3.23 ± 0.23	2.38 ± 0.21	1.36 ± 0.14
S.Em. ±	0.18	0.16	0.07	0.10	0.04	0.05
CD	0.52**	0.46**	0.19**	0.30 NS	0.14**	0.15**
F value	3.99	4.81	3.51	3.30	18.18	5.99

Note: Values are mean of three replications, S.Em.: Standard error of mean, C.D.: Critical difference, **Significant @ 1%, NS-Non significant

Table.3 Comparison of physical properties of released varieties and advanced breeding lines of horsegram varieties

Varieties	Length (mm)	Breadth (mm)	L/B	100 kernel weight(g)	100 kernel volume (ml)	Bulk density (g/ml)
Released varieties	5.75 ± 0.39	3.90 ± 0.30	1.44 ± 0.13	3.27 ± 0.175	2.30 ± 0.24	1.42 ± 0.13
Advanced breeding lines	5.91 ± 0.29	3.84 ± 0.36	1.51 ± 0.13	3.17 ± 0.303	2.50 ± 0.00	1.27 ± 0.12
t value	NS	NS	3.007*	NS	3.508*	3.397*

Note: Values are mean of three replications, S.Em.: Standard error of mean, C.D.: Critical difference, *Significant @ 5%, NS-Non significant

Table.4 Functional properties of different horsegram varieties

Varieties	Hydration capacity (g/grain)	Hydration index	Swelling capacity (ml/grain)	Swelling index
Released varieties				
AK42	0.033 ± 0.001^{ab}	0.009 ± 0.0005^{ab}	0.035 ± 0.00^{b}	0.014 ± 0.00^{d}
AK44	0.034 ± 0.001^{ab}	0.009 ± 0.0005^{ab}	0.035 ± 0.00^{b}	0.014 ± 0.00^{d}
DHG01	0.036 ± 0.001^{a}	0.01 ± 0.00^{a}	0.04 ± 0.00^{a}	0.016 ± 0.00^{c}
GPM06	0.034 ± 0.002^{ab}	0.01 ± 0.001^{a}	0.038 ± 0.002^{a}	0.019 ± 0.001^{a}
KBHG01	0.024 ± 0.013^{c}	0.009 ± 0.00^{abc}	0.03 ± 0.00^{b}	0.012 ± 0.00^{e}
CRHG22	0.028 ± 0.001^{abc}	0.008 ± 0.0005^{bc}	0.033 ± 0.002^{b}	0.017 ± 0.00^{b}
CRHG23	0.028 ± 0.001^{abc}	0.009 ± 0.0005^{ab}	0.035 ± 0.00^{b}	0.017 ± 0.00^{b}
Advanced breeding lines				
VHG13-01	0.024 ± 0.001^{c}	0.007 ± 0.0005^{d}	0.02 ± 0.00^{e}	0.008 ± 0.00^{g}
VHG15	0.029 ± 0.001^{abc}	0.009 ± 0.0005^{ab}	0.025 ± 0.00^{d}	0.01 ± 0.00^{f}
VHG44	0.027 ± 0.001^{bc}	0.009 ± 0.00^{abc}	0.025 ± 0.00^{d}	0.01 ± 0.00^{f}
VHG935	0.026 ± 0.002^{c}	0.008 ± 0.0005^{cd}	0.025 ± 0.00^{d}	0.01 ± 0.00^{f}
VHG938	0.035 ± 0.001^{a}	0.01 ± 0.00^{a}	0.035 ± 0.00^{b}	0.014 ± 0.00^{d}
Mean ± SD	0.030 ± 0.005	0.009 ± 0.0008	0.031 ± 0.006	0.013 ± 0.003
S.Em. ±	0.005	0.005	0.005	0.005
C.D.	0.016*	0.016**	0.016**	0.016**
F value	3.617	5.745	84.909	142.818

Note: Values are mean of three replications, S.Em.: Standard error of mean, C.D.: Critical difference, *Significant @ 5%, **Significant @ 1%

Table.5 Comparison of functional properties of released varieties and advanced breeding lines of horsegram varieties

Varieties	Hydration capacity (g/grain)	Hydration index	Swelling capacity (ml/grain)	Swelling index
Released varieties	0.031 ± 0.005	0.009 ± 0.0006	0.035 ± 0.026	0.015 ± 0.002
Advanced breeding lines	0.0286 ± 0.004	0.008 ± 0.0009	0.026 ± 0.005	0.010 ± 0.002
t value	NS	NS	6.16**	7.18**

Note: Values are mean of three replications, **Significant @ 1%, NS-Non significant

Table.6 Comparison of per cent germination of released and advanced breeding lines of horsegram varieties

Varieties	Per cent germination (%)
Released varieties	87.38 ± 5.58
Advanced breeding lines	84.00 ± 7.11
t value	NS

Note: Values are mean of three replications, NS-Non significant

Table.7 Correlation between physical properties and functional characteristics of horsegram varieties

	Length	Breadth	L/B ratio	Weight	Volume	Bulk density	Hydration capacity	Hydration index	Swelling capacity	Swelling index
Length	1	0.160	0.525**	0.293	0.190	0.041	0.276	0.212	0.059	0.031
Breadth		1	-0.512**	0.330*	0.156	0.092	0.360*	0.280	0.322	0.164
L/B ratio			1	-0.123	-0.005	-0.078	-0.145	-0.123	-0.279	-0.194
Weight				1	0.192	0.474**	0.332*	0.429**	0.438**	0.218
Volume					1	0.759**	0.065	0.100	0.372*	0.696**
Bulk density						1	0.265	0.367*	0.590**	0.742**
Hydration capacity							1	0.668**	0.624**	0.486**
Hydration index								1	0.718**	0.577**
Swelling capacity									1	0.905**
Swelling index										1

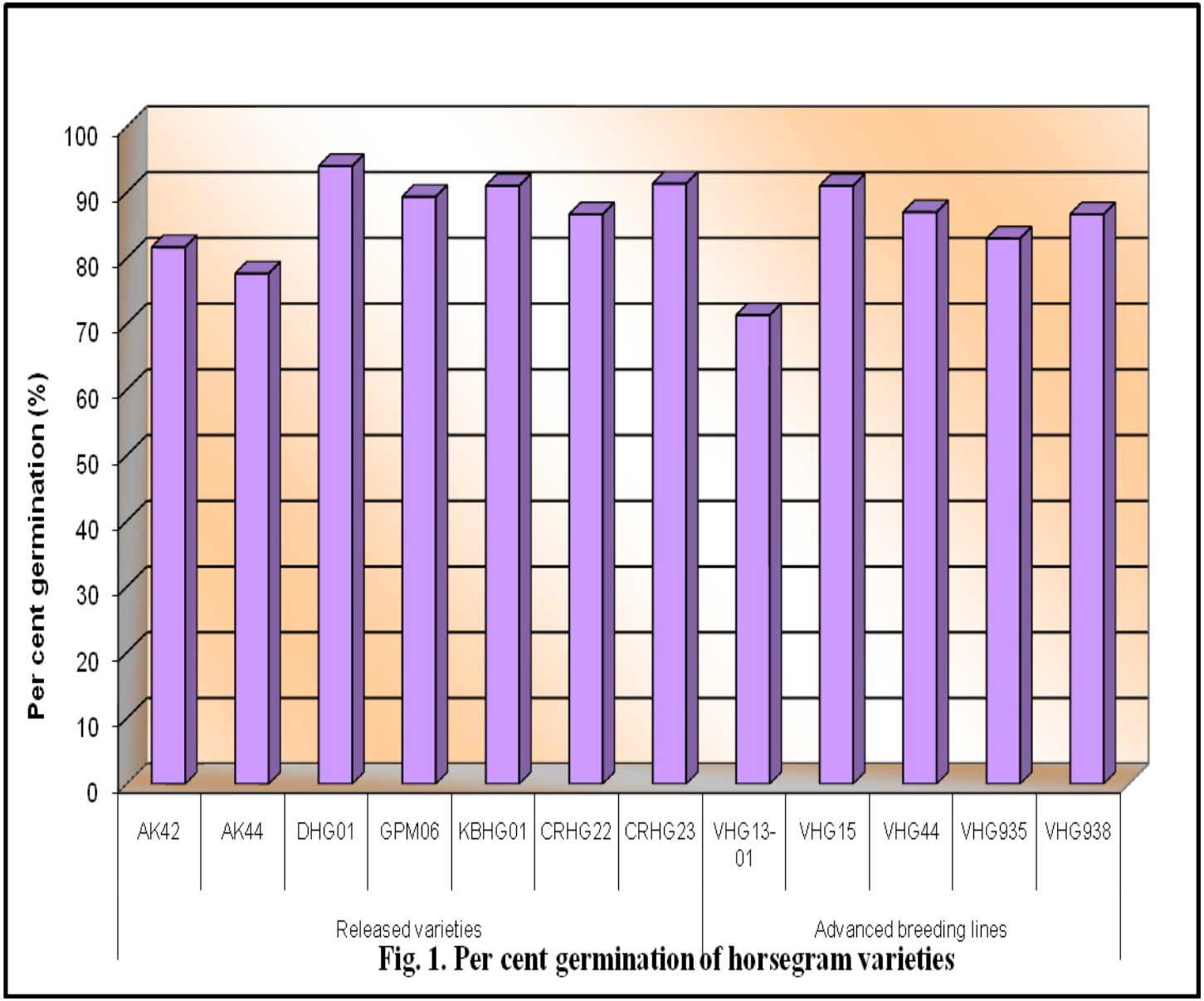

Fig. 1. Per cent germination of horsegram varieties

Per cent germination

Per cent germination of horsegram varieties

Per cent germination of horsegram varieties is presented in Figure 1. The varieties differed significantly ($p \leq 0.01$). The per cent germination in horsegram varieties ranged from 71.33-94 per cent. Lowest per cent germination was observed in VHG13-01 and highest was observed in DHG01, followed by CRHG 23 (91.33 %) and KBHG01 (91 %). Khatun *et al.,* (2013) showed slight difference in value of per cent germination from the present study. The reason may be due to the differences in functional characteristics and physical properties.

Per cent germination between the released varieties and advanced breeding lines of horsegram

Table 6 showed comparison of per cent germination between released and advanced breeding lines of horsegram varieties. There was no significant difference between the varieties for per cent germination. Released varieties showed higher per cent germination (87.38 %) compared to advanced lines (84 %).

Correlation between physical and functional characteristics of horsegram varieties

Table 7 depicts the correlation between physical and functional characteristics of horsegram varieties. From the table it is clear that there was significant positive correlation ($p \leq 0.01$) between length to breadth ratio and breadth was positive and significantly correlated with weight and hydration capacity whereas breadth was negatively correlated with length to breadth ratio. The significant positive correlation was between weight to bulk density and also with all the functional properties (hydration capacity, hydration index, swelling capacity and swelling index). Volume of the grains was significantly and positively correlated with bulk density, swelling capacity and swelling index. Significant positive correlation was found between hydration capacity to hydration index, swelling capacity and swelling index, hydration index to swelling capacity and swelling index and swelling capacity to selling index.

Thus, released varieties had higher values for physical parameters *i.e.,* length and breadth and functional properties *i.e.,* hydration capacity, hydration index, swelling capacity, swelling index and per cent germination compared to advanced breeding lines.

Acknowledgement

The data presented in the article is part of M.H.Sc. thesis by the first author to the University of Agricultural Sciences, Dharwad, and Karnataka, India.

The data is also presented as poster in Post Graduate Research Conference-2018 and AFSTI-ICFoST 2017.

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How to cite this article:

Aishwarya V. Patil and Kasturiba, B. 2018. A Study Physical Properties and Functional Characteristics of Selected Horsegram (*Macrotyloma uniflorum* (Lam) Verdc.) Varieties. *Int.J.Curr.Microbiol.App.Sci.* 7(09): 3184-3194. doi: https://doi.org/10.20546/ijcmas.2018.709.396