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Genetic Variability Studies for WUE Related Traits in F_2 Mapping Population of Castor (*Ricinus communis* L.)

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A B S T R A C T

Castor (*Ricinus communis* L.) an important non edible oil seed crop has great industrial value. India has been one of the major contributors in production and trade of castor oil and its derivatives. 400 castor F_2 mapping population generated from a cross between PCS 106 and PCS 345 was studied for the variability in ten WUE related physiological traits and six yield contributing traits. The study was conducted during Kharif season of 2015-16. The data was subjected to analysis of variance and was found that the germplasm differed significantly for all the characters studied. The estimates of genotypic and phenotypic variances were worked out for all the characters. While considering the WUE traits high GCV estimates were observed for leaf area (34.74%), photosynthetic rate (20.62%), stomatal conductance (28.50%), transpiration rate (36.32%) and extrinsic WUE (40.57%). In the present investigation both WUE related and yield characters showed high heritability (>60%) indicating low environmental effect and high capacity of the characters for the transmission to subsequent generation.

Introduction

Castor during its life cycle, suffers from biotic and abiotic stresses. Drought, a complex combination of stresses, involves both moisture stress and high temperature stress. Although some agronomic interventions to conserve soil moisture and enhance Water Use Efficiency (WUE) are available, identification of castor varieties tolerant to drought and efficient in water use offers the best long term and cost effective solutions. Drought tolerance in any crop depends on its intrinsic capabilities to maintain high WUE. Identification of reliable traits for screening castor genotypes for drought tolerance as well as availability of genotypic variability for these traits is the research priority.

WUE, a quantitative character governed by many genes with small effect has been coupled with high environmental effect.

Therefore traits related to WUE would be important traits for the breeder to enhance the WUE coupled with high yield. Hence, Specific Leaf Area (SLA) and Soil Plant Analysis development (SPAD) Chlorophyll Meter Reading (SCMR) have been used in the study. Further results from the previous study on SLA have shown the consistent and significant inverse correlation of WUE and yield. However SCMR shown the positive association with WUE and yield (Nageshwara Rao *et al.,* 2001).

Other leaf-related traits such as size or shape can influence WUE by affecting the rate of transpiration per unit of surface (Pallardy, 2008). Besides, SLA could affect photosynthetic capacity by modifying photosynthesis-nitrogen relations (Reich *et al.*, 1998).

Intrinsic WUE_i (μmol CO_2 mol H_2O^{-1}) is defined as the ratio of net CO_2 assimilation rate to stomatal conductance to water vapor. According to its definition, WUE_i can be considered the component of WUE submitted to plant regulation by means of stomatal control (Bacon *et al.,* 2004).

A large number of these studies showed variation in WUE_i at the provenance or population level (Aranda *et al.,* 2010). The chlorophyll fluorescence is an important measurement of photosynthetic efficiency of crops. The high ratio of variable to maximum fluorescence (Fv/ Fm ratio) is proportional to quantum yield showing high degree of photosynthesis (Gitelson *et al.,* 1998).

Significant genetic components for physiological traits were found for several species (Scotti *et al.,* 2010), suggesting that genetic control over these traits could be important. However, selecting genotypes with high WUE is a useful strategy in breeding for high WUE (Condon *et al.,* 2004).

Breeders very often use segregating populations as source population to exercise selection for identifying homozygous lines with better performance to develop varieties. At the same time, the breeding lines from the advanced generations are also used as parental lines for developing commercially exploitable heterotic hybrids. But, most often the source of early generations *i.e.,* F3, F4, F5 and F6 segregating populations offer wider opportunities for achieving high success, because of wider genetic base (Mallikarjun and Savithramma, 2017).

Genetic variability is pre-requisite for improving any crop plant. In any crop improvement programme, germplasm serves as a valuable source of base population, which offers much scope for further improvement. The coefficient of variation expressed in phenotypic and genotypic levels are used to compare the variability observed among different characters. Hence, knowledge about the variability using parameters like genotypic co-efficient of variation (GCV) and phenotypic co-efficient of variation (PCV) is of paramount importance for an efficient breeding programme in crops like castor.

The primary aim of the breeder is to improve the available genotypes by evolving superior varieties. Evolving superior genotypes would be effective, only when the existing variability in the chosen material is wide. The observed variability for any character is the result of interaction of genotype with environment.

Hence, it becomes necessary to partition the overall phenotypic variability into heritable and non-heritable components of variability to have an effective selection for superior genotypes (Radhamani and Ushakumari, 2013). Thus the present investigation was taken up to know the heritability estimates that aid in determining the relative amount of heritable portion in variation for WUE traits.

Materials and Methods

400 castor F_2 mapping population derived from a cross between Palem Castor Selection (PCS)-345 and PCS-106 genotypes having contrasting characters for drought were studied. The material was grown at College Farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar during september-2015 to February-2016. The distance between two successive rows was 90 cm, while within a row was 60 cm. Observations were recorded for various physiological traits related to WUE *i.e.*, leaf area, specific leaf area (SLA), relative water content (RWC), SPAD chlorophyll meter reading (SCMR), gas exchange measurements and chlorophyll fluorescence and seed yield and its component traits. Genotypic and phenotypic coefficient of variances was estimated based on the formula given by Burton (1952) and heritability and genetic advance were calculated according to Allard (1960).

Results and Discussion

Analysis of variance revealed highly significant differences for all the 16 characters indicating presence of high amount of variability within the F_2 population under study. The variability estimates such as PCV, GCV, heritability and genetic advances as per cent of mean have been presented (Table 1).

Among the F_2s, stomatal conductance and leaf area were distinct for its lowest mean values of 0.52 mole H_2O m^{-2} sec^{-1} and 4.16 cm^{-2} and highest mean values were observed for Intrinsic WUE (31.23 μmol CO_2 mol H_2O^{-1}), number of capsules/spike (42.98), Seed Yield/ Plant (100.31g) and Total Dry Matter (227.01g) (Table 1).

In the present study phenotypic and genotypic coefficient of variations ranged from 0.516, 0.472% for SLA and 42.20, 40.57% for Extrinsic WUE. Maximum phenotypic and genotypic variances were observed for leaf area (34.89 to 34.74%), photosynthetic rate (21.75 to 20.62%), stomatal conductance (29.51 to 28.50%), transpiration rate (37.19 to 36.32%), extrinsic WUE (42.20 to 40.57%), number of spikes per plant (32.50 to 26.44%), number of capsules on primary raceme (34.69 to 31.57%), seed yield per plant (30.05 to 28.62%) and TDM (33.90 to 23.78%). While minimum variances were shown by SLA (0.516 to 0.472%) and SCMR (7.49 to 4.88%) (Table 1). Little difference between PCV and GCV for all the traits indicated that the least role played by environment on these characters (Radhamani and Ushakumari, 2013).

The amount of genotypic variance present for a trait in a population influences estimates of heritability. More divergent parents yield a population that is more genetically variable. A large phenotypic variance would provide the breeder with a wide range of variability from which selection could be practiced (Acquaah, 2012).

Prince (2013) observed high GCV and PCV for leaf area (29.4, 29.41%) whereas low GCV and PCV (12.62, 12.74%) for SLA was recorded. Syed Sab *et al.*, (2018) observed low GCV and PCV for SCMR (8.21 and 9.91%). Same results were observed by Nandini *et al.*, 2011 from their studies on heritability, observed moderate heritability, GCV, PCV and genetic advance for SCMR, and pod weight per plant. They also reported the traits that conferred water use efficiency, high SCMR and low SLA that showed moderate to high heritability and moderate to low Genetic Advance as per Mean.

They conferred that there was more scope for bringing improvement in SCMR through phenotypic selection than in SLA.

Savita *et al.,* (2014) reported low GCV and PCV (%) for relative water content (RWC). Venkatesan *et al.*, (2017) observed high GCV and PCV in stomatal conductance (50.73%, 76.33%) followed by transpiration rate (22.09%, 33.81%), whereas moderate GCV were observed in photosynthetic rate (15.38%, 15.57%). Dhavan (2015) recorded highest PCV and GCV for stomatal conductance (18.83% and 15.90%) and moderate PCV and GCV were recorded for photosynthetic rate (10.73% and 8.90%) and chlorophyll content (9.02% and 7.03%).

Dapke *et al.,* 2016 reported high GCV and PCV for number of capsules on primary raceme and seed yield per plant. Omkarappa *et al.,* (2010) reported high GCV for number of capsules in primary spike in castor. Rajesh *et al.*, (2010) reported high GCV for single plant yield. Patel *et al.,* (2010) recorded high GCV for the characters viz., number of capsules on primary spike and seed yield per plant. As yield and its attributes are highly influenced by the environment, it is difficult to conclude whether the observed variability is heritable or not. Therefore, it becomes essential to partition the observed variability into heritable and non-heritable components. GCV along with heritability estimates would be better effective for selection.

Heritability has been reported to be a good index of the transmission of characters from parents to offspring (Falconer, 1967). In the present investigation all the characters showed high heritability indicating low environmental effect and high capacity of the characters for the transmission to subsequent generation (Table 1).

Table.1 PCV %, GCV %, H^2 (%) and GA as % of mean for different characters in castor

Trait	Mean	Coefficient of variance		Broad sense heritability (H^2) (%)	Genetic Advance as % mean (GAM)
		PCV (%)	GCV (%)		
Leaf area (cm^{-2})	603.05	34.89	34.74	99	71.24
SLA (cm^{-2} g^{-1})	4.16	0.51	0.47	83	0.89
RWC (%)	78.26	10.63	9.55	81	17.65
SCMR	45.13	7.49	4.88	42	6.55
Pn (μ mole CO_2 m^{-2} sec^{-1})	24.44	21.75	20.62	90	40.27
gs (mole H_2O m^{-2} sec^{-1})	0.52	29.51	28.50	93	56.67
T (m mol H_2O m^{-2} sec^{-1})	6.84	37.19	36.32	95	73.11
Intrinsic WUE (Pn/gs)	31.23	20.84	18.35	78	33.27
Extrinsic WUE (Pn/T)	3.91	42.20	40.57	92	80.33
Chlorophyll fluorescence (Fv/Fm)	0.61	11.59	10.81	86	20.54
No. of spikes	7.52	32.50	26.44	66.2	44.34
Effective Spike Length (cm)	24.05	22.81	13.58	35	16.66
No of Capsules/Spike	42.98	34.69	31.57	83	59.17
100 Seed Weight (g)	28.71	23.76	10.08	18	8.81
Seed Yield/ Plant (g)	100.31	30.04	28.61	91	56.14
Total Dry Matter (TDM, g)	227.01	33.90	23.78	49	34.37

Table.2 Comparative statement based on estimates of different genetic parameters for 16 characters in F_2 generation of castor

Trait	Genetic parameters	Gene effects	Influence of environment
Leaf area (cm^{-2})	High h^2 and high GAM	additive	low
Pn (µ mole CO_2 m^{-2} sec^{-1})			
gs (mole H_2O m^{-2} sec^{-1})			
T (m mol H_2O m^{-2} sec^{-1})			
Intrinsic WUE (Pn/gs)			
Extrinsic WUE (Pn/T)			
Chlorophyll fluorescence (Fv/Fm)			
No. of spikes			
No of Capsules/Spike			
Seed Yield/ Plant (g)			
RWC (%)	High h^2 and moderate GAM	Additive	low
SLA (cm^{-2} g^{-1})	High h^2 and low GAM	Non additive	low
Total Dry Matter (TDM, g)	Moderate h^2 with high GAM	Additive	medium
Effective Spike Length (cm)	Moderate h^2 with moderate GAM	Additive and Non additive	medium
SCMR	Moderate h^2 with low GAM	Non-additive	high
100 Seed Weight (g)	Low h^2 with low GAM	Non additive	high

In general, SLA had lower G×E interactions than did pod yield, TDM and WUE because it is more complex trait (Araus *et al.*, 2002).

Because of low G×E interactions, the use of surrogate trait as selection criteria might be useful for improving WUE if heritability is high. High heritability estimates for SLA has been reported (Upadhyaya, 2005). Therefore, it is promising as selecting criteria for WUE.

Heritability in broad sense was estimated for all the characters and it ranged from 18 % (100 seed weight) to as high as 99 % (leaf area). The range of genetic advance varied from 0.89 to 80.33% (Table 1).

High heritability coupled with high GAM was observed for leaf area (99%, 71.24%) followed by T (95%, 73.11%), gs (93%, 56.67%), extrinsic WUE (92%, 80.33%), seed yield per plant (91%, 56.14%), Pn (90%, 40.27%), chlorophyll fluorescence (86%, 20.54%), number of capsules on primary raceme (83%, 59.17%), intrinsic WUE (78%, 33.27%) and number of spikes per plant (66.2%, 44.34%) indicting their nature of least influenced by environment and are useful for breeding programme.

Prince (2013) reported high heritability coupled with high GAM for leaf area (99.94%, 60.54%). Venkateshan *et al.*, (2017) observed high heritability accompanied with high genetic advance in photosynthetic rate (67.60%, 31.30%) which indicated that the heritability was due to additive gene effects and selection might be effective. They also noticed moderate heritability with high genetic advance in stomatal conductance (50.54%, 76.19%) and transpiration rate (40.06%, 62.73%).

High heritability associated with moderate GAM was noticed in RWC (81%, 17.65%). Similar results for RWC (95%, 15.66%) were obtained by Savita *et al.,* 2014. High heritability with low GAM was observed in SLA (83%, 0.89%) (Table 2). High heritability coupled with low genetic advance indicates the greater role of non-additive genetic variance like epistatic and dominant interaction factors controlling the inheritance of these traits (Syed Sab *et al.,* 2018).

In our study moderate heritability with high GAM was recorded in TDM (49%, 34.37%). Moderate heritability with moderate GAM was observed in effective spike length (35%, 16.66%). Moderate heritability with low GAM was recorded in SCMR (42%, 6.55%) (Table 2). Similarly Dhavan (2015) recorded medium heritability coupled with low genetic advance for chlorophyll content (60.9%, 11.3%).

Low heritability with low GAM was observed in 100 seed weight (8.81%, 18%) (Table 2). Similarly John *et al.,* 2011 recorded low heritability and low GAM for 100-kernel weight indicating non-additive gene action in inheritance of the character. Hence, selection for the character is not effective in early segregating generations and has to be carried in later generations.

Goyat Binesh *et al.,* (2012) observed high heritability coupled with high genetic advance for number of siliquae, number of seeds per siliqua and seed yield per plant. Similar results were noticed by Dapke *et al.,* (2016) and Mallikarjun and Savithramma (2017) indicating the presence of additive gene action. Lira *et al.,* (2017) also observed heritability greater than 90% for yield. High heritability estimates contributed to the success of the selection, since they indicated the possibility that such characteristics are inherited.

The evaluated characteristics for castor achieved significant genetic effects. The genetic variance was the main component of phenotypic variation among genotypes. The selection is favored for the characteristics evaluated, as indicated by the high values of genetic variation coefficient, heritability and selective accuracy.

Maximum phenotypic and genotypic variances were observed for leaf area, gas exchange measurements, extrinsic WUE, number of spikes, number of capsules per spike, seed yield per plant and TDM while minimum variances were shown by SLA, RWC, SCMR and Chlorophyll fluorescence.

High heritability coupled with high genetic advance were observed for the characters *viz.,* leaf area, gas exchange measurements, intrinsic WUE, extrinsic WUE, chlorophyll fluorescence, number of spikes per plant, number of capsules on primary raceme, seed yield per plant indicating that these characters are governed by additive genes and simple phenotypic selection will be rewarding for improvement of these characters.

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References

Acquaah, G. 2012. Principles of Plant Genetics and Breeding. Second Edition. John Wiley & Sons, Ltd. Bowie State University, Maryland, USA.

Allard, R. (1960). Principle of Plant Breeding. John Wiley and Sons. Inc., New York

Aranda, I. Alía R. Ortega U. Dantas A.K. Majada J. 2010 Intra-specific variability in biomass partitioning and carbon isotopic discrimination under moderate drought stress in seedlings from four *Pinus pinaster* populations. *Tree Genet. Genom*. 6: 169–178.

Araus, J. L., Slafer, G. A., Reynolds, M. P. and Royo, C. 2002. Plant breeding and drought in C3 cereals: what should we breed for? *Annals of Botany*. 89: 925–940.

Bacon, M.A. Jones, H. Loveys B.R.*et al.*, 2004. *Water use efficiency in plant biology*. Wiley-Blackwell, Oxford. p327p.

Burton, G.W. (1952). Quantitative inheritance in grasses. Proc. Int. Grassland Congress, 1: 277-283.

Condon A. Richards R. Rebetzke G. Farquhar, G. 2004. Breeding for high water-use efficiency. *J. Exp. Bot*. 55:2447.

Dapke, J.S., Naik, M.R., Vaidya, G.B., Vanve, P.B., Narwade, A.V and Rajkumar, B.K. 2016. Genetic variability in castor (*Ricinus communis* L.). *European Journal of Biotechnology and Bioscience*. 4(4): 39-40.

Dhavan, J. P. 2015. *M. Sc. (Ag) Thesis*. Genetic Evaluation of Sesame Germplasm Based on Physiological and Yield traits. Submitted to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

Falconer, D.S. (1967). Introduction to quantitative genetics 4th Ed. Longman, NEW YORK (U.S.A.).

Gitelson, A. A., Buschmann, C and Lichtenthaler, H. K. 1998. Leaf chlorophyll fluorescence corrected for reabsorption by means of absorption and reflectance measurements. J. Plant Physiol. 152: 283–296.

Goyat Binesh, Singh, D. Autar Ram and Singh Amit. 2012. Estimation of selection parameters in elite gene pool of Indian mustard. Res. on Crops 13 (3): 1098-1101.

John, K., Raghava Reddy, P., Hariprasad Reddy, P., Sudhakar, P and Eswar Reddy, N.P.2011. Genetic variability for morphological, physiological, yield and yield traits in F2 populations of groundnut (*Arachis hypogaea* L.). *International Journal of Applied Biology and Pharmaceutical Technology*. 2 (4): 463-469.

Lira, E. G., Amabile, R. F., Fagioli, M and Montalvão, A. P. L. 2017. Genetic parameters, phenotypic, genotypic and environmental correlations and genetic variability on sunflower in the Brazilian Savannah. Cienc. Rural. 47(8): 1678-4596.

Mallikarjun, K and Savithramma, D.L. 2017. Genetic Variability, Heritability, Correlation and Regression in F3 and F4 Segregating Generation for Traits Related to WUE and Yield in the Cross NRCG 12274 × ICG 12370 of Groundnut (*Arachis hypogaea* L.). Int.J.Curr.Microbiol.App.Sci. 6(11): 3912-3921.

Nageswara Rao, R.C., Talwar, H.S and Wright, G.C. 2001. Rapid assessment of specific leaf area and leaf nitrogen in peanut (*Arachis hypogaea* L.) using a chlorophyll meter. *Journal of Agronomy*. 186: 175-182.

Nandini, C., Savithramma D. L. and Naresh Babu, N., 2011, Genetic variability analysis for surrogate traits of water use efficiency in F8 recombinant inbred lines of the cross NRCG 12568 × NRCG 12326 in groundnut (*Arachis hypogaea* L.). Electronic J. Pl. Bre., 2(4): 555-558.

Omkarappa, T., Hanumanthappa, D.C., Kumar Ajaj, J. and Ajay (2010). Correlation and path analysis of yield attributing traits in hybrids of castor, (*Ricinus communis* L.). J. Oilseeds Res., 27:72-74.

Pallardy S.G. 2008. *Physiology of woody plants.* 3th edn. Elsevier, Burlington, VT. p412 p.

Patel, J.R., Saiyed, M.P., Patel, C.G., Bhatt, R.K. and Bhatt, V.K. (2010). Genetic divergence in castor (*Ricinus communis* L.). Internat. J. agric. Sci., 6(1): 113-115.

Prince, CH. 2013. *M. Sc Thesis*. Identification of qtl governing water use efficiency and root traits in a recombinant inbred population of groundnut. University of Agricultural Sciences, GKVK, Bangalore-560065.

Radhamani, T and Ushakumari, R. 2013. Variability studies in castor germplasm accessions (*Ricinus communis* L.). *Asian Journal of Bio Science*. 8(1): 69-71.

Rajesh, V., Rao, P. Venkata Ramana, Gouri Shankar, V., Reddy, A. Vishnuvardhan and Pavani, J.V.P. (2010). Variability, heritability and genetic advance in castor (*Ricinus communis* L.). J. Oilseeds Res., 27:90-91.

Reich, P. Ellsworth, D. Walters M. 1998. Leaf structure (specific leaf area) modulates photosynthesis–nitrogen relations: evidence from within and across species and functional groups. *Funct. Ecol*. 12: 948–958.

Savita, S. K. Kenchanagoudar, P. V and Nadaf, H. L. 2014. Genetic variability for drought tolerance in advanced breeding lines of groundnut (*Arachis hypogaea* L.). Karnataka J. Agric. Sci., 27(2): (116-120).

Scotti I. Calvo-Vialettes L. Scotti-Saintagne C. Cotterop M. Degen B. Bonal D. 2010. Genetic variation for growth, morphological and physiological traits in a wild population of the neotropical shade-tolerant rainforest tree *Sextonia rubra* (Mez) av der Werff (Lauraceae). *Tree Genet. Genom*. 6:319–329.

Syed Sab, J., Shanthala, D., Savithramma L and Bhavya, M. R. 2018. Study of Genetic Variability and Character Association for Water Use Efficiency (WUE) and Yield Related Traits Advance Breeding Lines of Groundnut (*Arachis hypogea* L.). Int.J.Curr. Microbiol.App.Sci. 7(6): 3149-3157.

Upadhyaya, H.D. 2005. Variability for drought resistance related traits in the mini core collection of peanut. *Crop Science*. 45: 1432–1440.

Venkatesan, M., Sowmiya, C. A and Anbarasi, B. 2017. Studies on variability, heritability and genetic advance analysis in rice (*Oryza sativa* L.) under submergence. International Journal of Agricultural Sciences. 13 (1): 49-52.

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