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PREFACE

The 3rd International Symposium for Sustainable Humanosphere 2013 attracted the interest of scientists from Indonesia and Japan. The symposium covered the disciplines of community-based development and social economic science (climate change and society; ecosystem and community; the economical of natural resources; the role of traditional knowledge and values in managing ecosystems; women and natural resources), atmospheric science (airpollution; equatorial atmosphere; global climate change models; land-ocean weather systems; radar observations; solar activities; space environment; weather patterns), biosphere science (agricultural in changing world; animal ecology and animal husbandry; anthropological approach; bio-indicator; ethnobotany; food security; human development index), geosphere science (earth geological dynamics and natural disasters; earth carbon cycle dynamics; heat, water and CO; hydrology and water management system; land resource management), wood science and technology (biomass conversion; carbonized wood based composites; cellulose; chemical, physical and mechanical properties of wood; timber structure; wood for energy; wood cell formation; wood biochemistry; wood anatomy and plant physiology; wood deteriorating organisms; wood preservation; wooden construction; wood-based material; wood adhesive), wood and urban pest management (insect pest management, ecology and biology of urban pests, control of urban pest including biological, cultural, mechanical, physical and chemical controls), and forest science (biodiversity and society; biodiversity in tropical plantation forests; climate change and biodiversity; forest biomass dynamics; forest carbon accounting and monitoring; forest fire; invasive species; intensive silviculture; structure, growth and function; tree biotechnology). The technical program consisted of 38 oral presentations under 11 sessions and 19 poster presentations.

This publication is a compilation of presented papers. Every effort has been carried out to retain the original meaning and views of authors during the editing processes. All claims on trade products and processes and views expressed do not necessarily imply endorsement by the editors.

We believe that this publication will be a useful source of information and achieved its primary objective of disseminating new experiences and information to researchers, academics, policy makers and students.

The organization of this international gathering and compilation of the proceedings could not have been achieved without the combined effort of all members of the organizing committee and the supports of Research Institute for Sustainable Humanosphere (RISH), Center for South East Asian Studies (CSEAS) Kyoto University, International Center for Interdisciplinary and Advanced Research (ICIAR) – LIPI, University of Bengkulu (UNIB). The editors hereby wish to acknowledge the contributions of all parties.

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CORRELATION AND PATH ANALYSES FOR DETERMINATION OF SELECTION CRITERIA IN CHILI PEPPER BREEDING FOR FRUIT YIELD IMPROVEMENT

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Abstract

Knowledge on trait association provides basic criteria for an efficient selection program. This study was undertaken to elucidate the most reliable fruit yield contributing traits in chili pepper. Measurements were made on 15 agronomic traits of 49 chili pepper families generated from a complete diallel cross of 7 parental lines. Analysis correlation revealed that fruit yield per plant had highly significant positive correlations with canopy diameter, fruit number, marketable yield, average fruit weight, and fruit length. Path coefficient analysis based on fruit yield per plant as the dependent variable indicated that positive direct effects of fruit number, marketable yield, average fruit weight, and fruit length were the main contributing traits to fruit yield per plant with the maximum effect was exhibited by fruit length. The significant correlation of canopy diameter with fruit yield per plant was mainly due to indirect effect over marketable yield. Both analyses suggested that chili pepper selection program for higher fruit yield could be based on these traits as selection criteria.

Key words: *chili pepper, fruit yield, correlation, path analysis, selection criteria*

Introduction

Chili pepper (*Capsicum annuum* sp.) almost always presents in Indonesian dishes making the crop as one of the most important vegetables in term of harvest area and production. The area under cultivation of chili pepper in Indonesia during 2011 was 237,253 ha with total production 1.4 million tones, whereas the annual consumption was 1.12 million tones [1]. This figure should indicate self sufficiency for national demand on chili pepper. Nevertheless, shortage is often occurred due to the use of low yielding genotypes and fluctuation in production patterns. Current average yield 6.07 tones ha^{-1} was comparatively lower than 21.5 and 14.2 ton ha^{-1} achieved by China and Thailand, respectively [2]. Development of high yielding cultivars, therefore, is the ultimate objective in chili pepper breeding program.

Fruit yield is the most important and complex trait for the genetic improvement of chili pepper [3]. It depends directly or indirectly dependent on a number of traits known as yield components. The knowledge of traits association will be helpful in determining the selection criteria for yield improvement for which direct selection is not effective. Correlation analysis generally reveals the degree of association among traits and degree of linear relation between these traits. It is not sufficient to describe causal relationship among traits and, hence, is not sufficient determine reliable selection criteria. Path analysis provides an effective means of partitioning the correlation coefficients into direct and indirect effects of the component characters on yield by which the selection criteria in crop breeding program for yield improvement can be logically devised [4]. Considering these stand points, the present study was undertaken to elucidate the most reliable fruit yield contributing traits in chili pepper as selection criteria in chili pepper breeding program.

Materials and Methods

This study was carried out on ultisol at Experiment Station of Agricultural Production Department orchard, University of Bengkulu during July 2011 and November 2011. Genetic materials consisted of 49 families of chili pepper generated from a complete diallel cross of 7 chili pepper lines, i.e. IPBC110, IPBC19, IPBC120, IPBC12, UNIBC GTS1, IPBC10, and IPBC 1. A randomized complete block design with 3 replications was used to allocate the genetic materials in 1.2 m x 3.6 m plots with 12 plants per plot. Seedlings were prepared by growing the seeds on plastic trays filled with a mixture of 1/2 soil, 1/4 compost, and 1/4 rice hull ash and maintained for 4 weeks. Seedlings from each family were transplanted on the experimental plots in a double row with spacing of 60 cm between rows and plants. All recommended cultural practices, including fertilizer application, weeding, pest and disease controls, and irrigation, were followed to rise healthy chili pepper plants.

Eight harvests at one week interval were made by hand picking the ripe fruits. Six randomly selected plants in each plot were observed for the following traits: plant height and first branch height (cm, measured at the first harvest); canopy diameter (cm, measured at the first harvest); leaf width and length (cm, mean width and length of 10 leaves per plant at the first harvest); days to first harvest (number of days from transplanting to first harvest); fruit number (number of fruits per plant from all harvest); marketable yield (number of non-defective fruits per plant from all harvest); average fruit weight (g, ratio between total weight of fruit per plant and number of fruits per plant); fruit length (cm, mean length of 10 fruits per plant); fruit diameter (mm, mean diameter of 10 fruits per plant); pericarp thickness (mm, mean pericarp thickness of 10 fruits per plant); seed number (number of seed per fruit considering 10 fruits per plant); pedicel length (cm, mean pedicel length of 10 fruits per plant); and fruit yield per plant (g, total fruit weight obtained in eight harvests).

Simple correlation analysis was performed to estimate the coefficient of correlation for every pair of the traits using IBM SPSS Statistics v19. Path analysis to estimate the direct and indirect effect to the fruit yield per plant was performed following procedure given by [5].

Result and Discussion

Estimations of correlation coefficients among the observed agronomic traits were presented in **Table 1**. Traits showing highly significant positive correlation with fruit yield per plant were canopy diameter, fruit number, marketable yield, average fruit weight, and fruit length. These findings were in accordance with [6,7,8,9]. Therefore, these five traits can be regarded as the yield components. In addition, degree and direction of these traits with the other traits were varied. Canopy diameter showed positive and highly significant correlation only with marketable yield. Fruit number had highly significant positive correlations with plant height, first branch height, and marketable yield, but it had highly significant negative correlations with average fruit weight, fruit diameter, and pericarp thickness. Average fruit weight was observed to have highly significant positive correlation with fruit length, fruit diameter, pericarp thickness, and pedicel length, but it had highly significant negative correlation with plant height, first branch height, and days to first harvest, beside with fruit number. Furthermore, fruit length conferred highly significant positive correlation with leaf length, seed number, and pedicel length alongside with average fruit weight, and highly significant negative correlation with leaf width and seed number.

Partition of coefficient correlations between fruit yield per plant and yield components by path analysis were shown in **Table 2**. The maximum positive direct effect to fruit yield per plant was exhibited by fruit length (0.575), followed by marketable yield (0.477), average fruit weight (0.426), fruit number (0.358). The importance of fruit length, average fruit length and fruit number in determining fruit yield has been reported by [10]. Highly significant positive correlation between canopy diameter and fruit yield per plant was mainly due to indirect effect over marketable yield. Similarly, Pedicel length had a comparable negative direct effect to fruit yield per plant but its total effect was relatively low. These results suggested that longer fruit, less defective fruit, heavier individual fruit, and more fruit per plant should be used as reliable criteria in the selection program for chili pepper yield improvement.

Table 1. Correlation coefficients among different pairs of agronomic traits of chili pepper

Trait	First branch height	Canopy diameter	Leaf width	Leaf length	Days to first harvest	Fruit Number	Marketable yield	Average fruit weight	Fruit length	Fr dian
Plant height	0.486**	0.074	-0.006	-0.488**	0.431**	0.555**	0.071	-0.578**	-0.273	-0.
First branch height		0.482**	0.175	-0.092	0.371**	0.458**	0.203	-0.426**	-0.206	-0.
Canopy diameter			0.082	0.363*	-0.123	0.350*	0.444**	-0.026	0.095	-0.
Leaf width				-0.049	0.066	0.068	-0.086	-0.303*	-0.621**	0.3
Leaf length					-0.364*	-0.231	0.049	0.384**	0.439**	-0.
Days to first harvest						0.340*	0.067	-0.471**	0.007	-0.4
Fruit Number							0.588**	-0.550**	-0.293*	-0.5
Marketable yield								0.102	0.158	-0.
Average fruit weight									0.598**	0.3
Fruit length										-0.
Fruit diameter										
Pericarp thickness										
Seed number										
Pedicel length										

Table 2. Path coefficients showing direct and indirect effects of different traits on fruit yield per plant

Trait	Direct effect	Indirect effect									
		Plant height	First branch height	Canopy diameter	Leaf width	Leaf length	Days to first harvest	Fruit Number	Marketable yield	Average fruit weight	Fruit length
Plant height	0.065	-	-0.017	0.004	0.000	0.010	-0.007	0.199	0.034	-0.246	-0.157
First branch height	-0.035	0.032	-	0.024	0.004	0.002	-0.006	0.164	0.097	-0.181	-0.118
Canopy diameter	0.050	0.005	-0.017	-	0.002	-0.007	0.002	0.125	0.212	-0.011	0.055
Leaf width	0.024	0.000	-0.006	0.004	-	0.001	-0.001	0.024	-0.041	-0.129	-0.357
Leaf length	-0.020	-0.032	0.003	0.018	-0.001	-	0.006	-0.083	0.023	0.163	0.252
Days to first harvest	-0.016	0.028	-0.013	-0.006	0.002	0.007	-	0.122	0.032	-0.200	0.004
Fruit Number	0.358	0.036	-0.016	0.018	0.002	0.005	-0.005	-	0.281	-0.234	-0.168
Marketable yield	0.477	0.005	-0.007	0.022	-0.002	-0.001	-0.001	0.210	-	0.043	0.091
Average fruit weight	0.426	-0.038	0.015	-0.001	-0.007	-0.008	0.007	-0.197	0.049	-	0.344
Fruit length	0.575	-0.018	0.007	0.005	-0.015	-0.009	0.000	-0.105	0.075	0.255	-
Fruit diameter	-0.044	-0.019	0.011	-0.004	0.008	0.001	0.008	-0.180	-0.098	0.164	-0.140
Pericarp thickness	0.024	-0.022	0.013	-0.003	-0.002	-0.001	0.007	-0.160	-0.013	0.218	0.072
Seed number	-0.006	0.020	0.005	-0.011	0.006	0.008	0.001	0.052	-0.022	-0.111	-0.336
Pedicel length	-0.346	-0.009	0.003	0.008	-0.014	-0.009	0.000	-0.108	0.063	0.221	0.508

Conclusion

Fruit yield per plant had highly significant positive correlations with canopy diameter, fruit number, marketable yield, average fruit weight, and fruit length. Path coefficient analysis based on fruit yield per plant as the dependent variable indicated that positive direct effects of fruit number, marketable yield, average fruit weight, and fruit length were the main contributing traits to fruit yield per plant with the maximum effect was exhibited by fruit length. The significant correlation of canopy diameter with fruit yield per plant was mainly due to indirect effect over marketable yield. Both analyses suggested that chili pepper selection program for higher fruit yield could be based on these traits as selection criteria.

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