A Rapid and Non-Destructive Method to Determine the Leaflet, Trifoliate and Total Leaf Area of Soybean

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ABSTRACT

The importance of rapid, non-destructive, and accurate measurements of leaf area for agronomic and physiological studies is well known. Several mathematical formulas have been derived for estimating leaf areas for numerous crops, but there is little information available for soybean (Glycine max L). This study aimed to develop prediction equations for estimating leaflet, trifoliate and total leaf areas using maximum length, L (cm), width, W (cm), length and width product, LW (cm) and green leaf dry matter, DM (g) of soybean leaves. For this purpose, an experiment was conducted using three cultivars of soybean (‘Dpx’, ‘Sahar’ and ‘Williams’), in 2009-2010, in the Faculty of Agronomy, Gorgan, Iran. During the growing season, leaves of randomly selected soybean plants were collected. Leaf area was measured with a digital leaf area meter, related dry matter also was weighed, leaf dimensions were determined with a ruler, too. Statistical analyses of soybean leaf areas were divided into three levels: leaflet, trifoliate and total leaf area. At each level, the predictive abilities of three regression equations (linear, power and binomial) were compared, with different independent variables for each equation. Our data indicate, however, that considerable savings of time, with little loss of predictive ability, could be possible by measuring only W or LW in each instance. In general, these analyses indicated that a single regression equation could be used at each level. Our findings revealed that pooled-based models (without respect to cultivar) are reliable for estimating leaflet, trifoliate and total leaf area. Researchers can use these models readily and without any inconvenience to save time and costs, especially where there is a lack of related equipment to measure leaf area.

Keywords: green leaf dry matter, length, models, width

INTRODUCTION

Leaves are the most important photosynthetic organ of the plant. Estimation of leaf area (LA) is an essential component of plant growth analysis and evapotranspiration studies. LA is a determinant factor in radiation interception, photosynthesis, biomass accumulation, transpiration and energy transfer by crop canopies. It is also important with respect to crop-weed competition and soil erosion (Jonckheere et al. 2004; Akram-Ghaderi and Soltani 2007). LA is useful in the analysis of canopy structure as it allows determination of leaf area index (LAI). Therefore, LA is measured in many different studies and its accurate measurement is necessary for understanding crop responses to experimental treatments. Although many methods are available for LA measurements, such as graded standards, these methods often are time consuming and laborious. Although sophisticated electronic instruments provide accurate and fast LA measurement, they are expensive, especially in developing countries. Hence need to develop economically cheaper and technically easier but sound methods are needed for LA measurement (Korva and Forbes 1997). Nondestructive methods allow the replication of measurements during the growth period, reducing some of the experimental variability associated to destructive sampling procedures (NoSmith 1992). They are very useful in studies of plant activity, which require a nondestructive method of measuring LA (Wendt 1967) and also when the number of available plants is limited. The use of regression equations to estimate LA is a nondestructive, simple, quick, accurate, reliable and inexpensive. The usual procedure of this method involves measuring maximum length (L), width (W) and area of a sample of leaves and then calculating the several possible regression coefficients, or leaf factors, to estimate areas of subsequent samples (Wiersma and Bailey 1975). Accurate and simple mathematical models eliminate the need for leaf area meters or time-consuming, geometric reconstructions (Gamiely et al. 1991). Montgomery (1911) first suggested that LA of a plant can be calculated from linear measurement of leaves. Such a mathematical equation for estimating LA reduces sampling effort and cost, may increase precision where samples of leaf size are difficult to handle. There are a number of prediction equations using leaf dimension measurements (L and W) for leaf area measurement of different crops and also, there are number of leaf area prediction models based on individual leaves, leaf weight or total aboveground biomass (Table 1). Leaves are formed in a characteristic pattern for each species, creating a specific leaf shape (Sinha 1999). Therefore, prediction models must be determined for each species, and for cultivars of a given species which presents different leaf shapes. Soybean, as the most important summer crop in Golestan province, North of Iran, has a valuable situation in cropping patterns which is cultivated just after wheat harvesting. A wide range of studies with different aims are underway in universities and research centers in which, in most cases, LAI measurement is needed. But LA measurement is time-consuming and laborious and needs special equipment, which is expensive, thus it seems that a simple measurement based on simple methods is needed to help researchers in this case. However, available information for non-destructive prediction of soybean (Glycine max L.) LA is scarce (Wiersma and Bailey 1975). The purpose of this study, therefore, was to develop prediction equations for estimating leaflet, trifoliate and total leaf areas by using L, W, length and width product (LW) and green leaf dry matter (DM) of soybean leaves.

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