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## SHORT COMMUNICATION

# DIFFERENCES IN PLANT GROWTH, DRY MATTER PARTITIONING, YIELD AND WATER USE EFFICIENCY OF MUNGBEAN×BLACK GRAM HYBRIDS UNDER RAINFED CONDITIONS

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## SUMMARY

**Six hybrids, three each with foliage morphology similar to mungbean and black gram were evaluated for plant growth and grain yield. Mungbean type produced higher yield than black gram type hybrids. Hybrids T1-18 and T2-36 showed rapid root growth and greater allocation of dry matter to grains. Biomass was positively related to total moisture use and seed yield to daily crop transpiration. Combined contribution of number of seeds pod$^{-1}$, seed size and pods plant$^{-1}$ ($R^2$=0.998) or the number of grains pod$^{-1}$ and seed size ($R^2$=0.997) towards grain yield indicated our primary concern to focus attention to improve the seed size of these legumes under rainfed conditions.**

*Key words*: **Dry matter partitioning, growth pattern, hybrid, soil moisture use**

Mungbean (*Vigna radiata* L.) and black gram (*V. mungo* L.) are two important pulses grown on light textured soils under rainfed conditions in Indian subcontinent. Mungbean cultivation spreads widely because of its superior digestibility while black gram has been identified as a high yielding pulse (Smartt 1990). Although the two crops are grown as rainfed, yet they show yield reduction when subjected to drought. Singh and Ahlawat (2004) after reviewing progress in productivity of the two crops suggested the necessity to develop abiotic stress tolerant plant types to increase productivity. Hybridization has been known to be the most potential tool for increasing genetic variability and yield potential of plants. Although the breeding programmes for development of hybrids of mungbean×black gram has been initiated, reports on morpho-physiological behavior and dry matter partitioning between root and shoot is not available. The present study was aimed to investigate the differences in soil moisture use, growth and partitioning of dry matter in different plant parts of mungbean×black gram hybrids along with standard cultivars under rainfed conditions.

Two experiments were conducted during the summer/monsoon seasons at the Research Farm of CCS Haryana Agricultural University, Hisar, India (20º 10'N latitude and 75º 45'E longitude, 215 m altitude). Six promising hybrids with foliage morphology resembling, three each to mungbean (T1-16, T1-18, T1-22) and black gram (T2-22, T2-36, T2-39) along with their respective standard cultivars K851 and T9 were planted in drought plots (45×10×2 m each concrete plot filled with similar light textured dunal sand) on 15 and 19 July. The experiments were laid out in randomized block design

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*Corresponding author, E-mail: dtr10@hau.ernet.in with three replications. The plant spacing was 45×25 cm on 15 July and 30×10 cm on 19 July sowing. Essential plant nutrients, 20 kg $ha^{-1}$ N through urea, 40 kg $ha^{-1}$ $P_2O5$ through diammonium phosphate, 20 kg $ha^{-1}$ $K_2O$ through muriate of potash and 25 kg $ha^{-1}$ $ZnSO_4$ were supplied as basal dose before sowing. Other micronutrients, such as iron, copper and manganese, were applied with pre-sowing irrigation. No post sowing irrigation was applied to the crop. A total of 221.3 mm of rainfall was received during the crop growth period. The soil moisture content was determined at fortnightly intervals from 0-30, 30-60 and 60-90 cm soil depths by a neutron moisture meter (Troxler, NC, USA).

For dry matter accumulation and partitioning, three plants were harvested from each plot to make one replication. Roots were washed clean and maximum root length was recorded to obtain root zone depth. Each plant was separated into roots, leaves, stems and pods and their dry weight was recorded after drying at 70 ºC for 24 h till constant weight. Leaf area was measured by an area meter (LI 3000, LICOR, INC., USA). Because of shorter maturity duration of hybrids, the growth measurements were terminated two weeks earlier in hybrids than in the standard cultivars. The number of pods $plant^{-1}$, grains $pod^{-1}$ and 1000-grain weight was recorded after final harvest and the plants were sun dried for 5 days to obtain total biomass and grain yield. Hybrids were harvested 50 DAS while genotypes were harvested 65 DAS. Data were subjected to analysis of variance using online Statistical Analysis Package (OPSTAT, Computer Section, CCS Haryana Agricultural University, Hisar, India). Tests of significance were done at P<0.05 and P<0.01. Correlation and regression were also calculated.

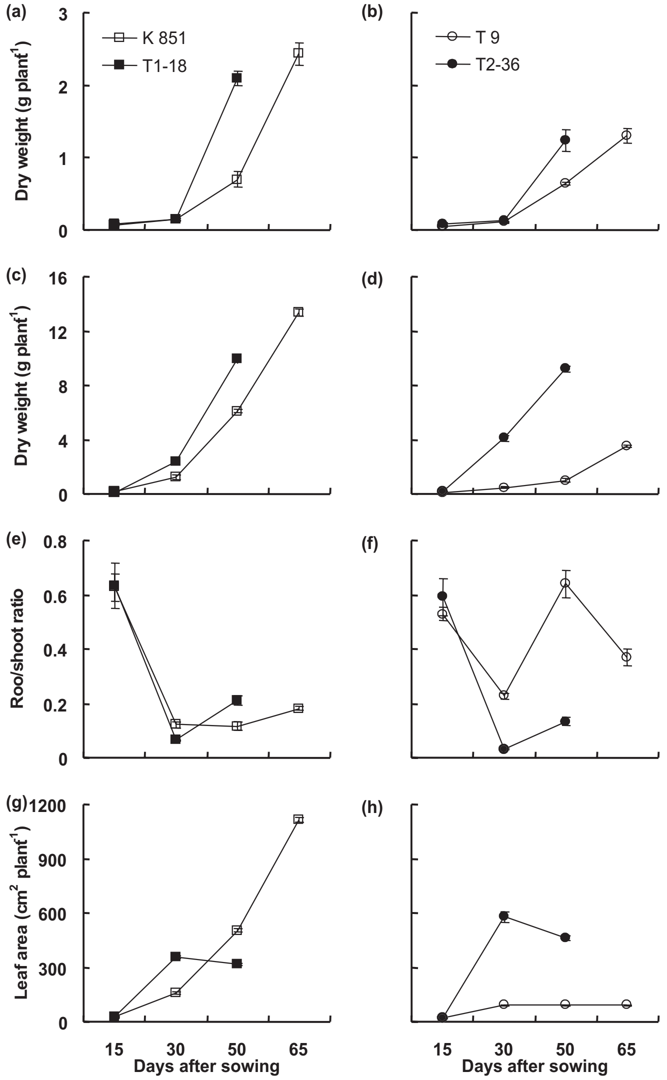

**Fig. 1. Changes in dry weight of roots (a, b) and shoots (c, d), root/shoot ratio (e, f) and leaf area (g, h) of mungbean and black gram genotypes, respectively. Vertical bars represent ± standard deviation of mean of 3 observations (n=9).**

A substantial genetic variability was observed for growth pattern, harvest index and water use efficiency among the genotypes. The genotypes showing rapid development of deep roots were able to maintain vigorous shoots and large photosynthetic area (Fig. 1 and 2). Therefore, an early and rapid establishment of deep roots seems to be an important trait for light textured soils in which water moves at a fast rate together with soluble nutrients to the lower layers of soil. The genotypes with slow rate of root extension probably deprived of both water and soluble nutrients in these soils (Turner and Begg 1981). Interestingly, despite the short maturity duration and lesser root dry weight; the root zone depth of hybrids was greater compared to standard cultivars. The early maturity duration matched well with the period of high probability of rainfall (in the months of July and August) of northwestern parts of India. The two hybrids (T1-18 and T2-36) accumulated the shoot dry matter at a rapid rate and began to remobilize a greater proportion to grains 30 DAS to maturity (Fig. 1). On the contrary, in genotype T1-16 a greater proportion of assimilates were allocated to vegetative parts

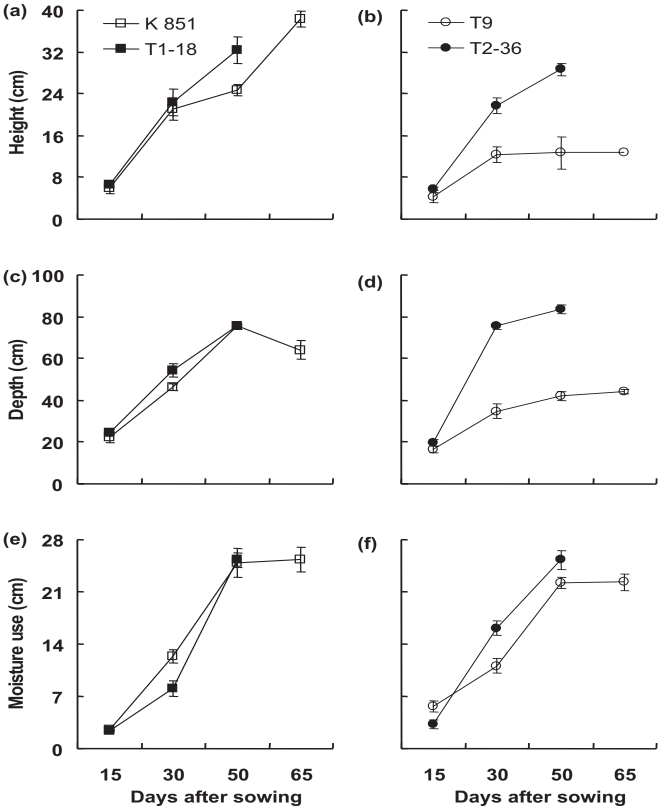

**Fig. 2. Changes in plant height (a, b), root depth (c, d) and soil moisture use (e, f) of mungbean and black gram genotypes, respectively. Vertical bars represent ± standard deviation of mean of 3 observations (n=9).**

consistently from 15 DAS to maturity. A similar tendency was observed in cultivar K851 for partition of assimilates to stem and leaf, but this genotype showed economy in assimilate allocation to roots 50 DAS. This could be the probable reason for higher allocation of assimilates from shoots to grains in cultivar K851 over hybrid T1-16 (Passioura 1986). Genotypes with smaller allocation of dry matter to roots were T1-18 and T2-36, which were able to sustain not only good shoot growth, but also extracted a substantial amount of water from the soil during the crop season (Table 1 and 2). A relatively low diversion of assimilates to roots and escape of moisture stress due to short maturity duration could be the reasons for higher allocation of dry matter to grains in hybrids T1-18 and T2-36. Among late maturing genotypes, the higher allocation of dry matter to grains in hybrid T1-22 was probably linked to either its significantly greater soil moisture extraction capacity (Turner and Begg 1981), or inherent genetic capacity for partitioning of greater assimilates to grains (Donald and Hamblin 1976, Kumar and Sharma 2009).

The measurements of water use, partitioning of dry matter and yield components allowed us to establish the association of these parameters to grain yield. The seed yield was positively related to daily rates of crop transpiration ($R^2$=0.36, $P<0.05$, Table 2). High daily

**Table 1.** Variations in plant density, yield and harvest index (19 July sowing).

| Genotype | Pods plant$^{-1}$ | Grains pod$^{-1}$ | 1000-seed weight (g) | Grain yield (kg ha$^{-1}$) | Shoot biomass (kg ha$^{-1}$) | Total biomass* (kg ha$^{-1}$) | Harvest index based on | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Shoot biomass | Total biomass |
| Black gram | | | | | | | | |
| T9 | 7.2 | 4.5 | 16.5 | 333 | 1000 | 1600 | 0.33 | 0.21 |
| T2-22 | 14.2 | 8.1 | 48.0 | 1133 | 3300 | 3967 | 0.34 | 0.29 |
| T2-36 | 18.7 | 8.6 | 56.0 | 1333 | 3033 | 3467 | 0.44 | 0.38 |
| T2-39 | 16.2 | 5.7 | 46.0 | 1033 | 2033 | 2200 | 0.51 | 0.47 |
| Mungbean | | | | | | | | |
| K851 | 18.5 | 8.9 | 54.0 | 1333 | 4500 | 5266 | 0.30 | 0.25 |
| T1-16 | 6.7 | 9.3 | 35.0 | 933 | 7366 | 8766 | 0.13 | 0.11 |
| T1-18 | 20.0 | 9.3 | 90.5 | 2167 | 3666 | 4000 | 0.59 | 0.54 |
| T1-22 | 21.5 | 9.7 | 73.0 | 1767 | 3833 | 4666 | 0.46 | 0.38 |
| LSD (P<0.05) | 3.7 | 1.4 | 29.8 | 461 | 1570 | 774 | 0.12 | 0.14 |

*Root weight included

**Table 2.** Variation in soil moisture use and water use efficiency of mungbean and black gram genotypes.

| **Genotype** | **Seasonal moisture use (mm)** | **Daily moisture use (mm d$^{-1}$)** | **Water use efficiency (kg ha$^{-1}$ cm) on the basis of** | | |
|---|---|---|---|---|---|
| | | | **Grain yield** | **Shoot biomass** | **Total biomass*** |
| Black gram | | | | | |
| T9 | 241 | 3.7 | 13.8 | 41.5 | 66.4 |
| T2-22 | 271 | 4.2 | 41.8 | 121.8 | 146.4 |
| T2-36 | 274 | 5.5 | 48.7 | 110.7 | 126.5 |
| T2-39 | 229 | 3.5 | 45.1 | 88.8 | 96.1 |
| Mungbean | | | | | |
| K851 | 267 | 4.1 | 49.9 | 168.5 | 197.2 |
| T1-16 | 274 | 4.2 | 34.1 | 268.8 | 319.9 |
| T1-18 | 266 | 5.3 | 81.4 | 137.8 | 150.4 |
| T1-22 | 301 | 4.6 | 58.7 | 127.3 | 155.0 |
| LSD (P<0.05) | 18 | 0.6 | 16.2 | 55.4 | 64.1 |

*Root weight included

moisture use was recorded only in genotypes which had either short maturity duration (T1-18 and T2-36) or greater moisture extraction capacity (T1-22). This indicated that these genotypes did not suffer due to moisture stress and attained high water use efficiency due to high productivity, probably by allocation of greater proportion of assimilates to grains. Thus to improve grain yield of crops in rainfed areas, one must increase water passing through crop in transpiration, increase the water use efficiency and/or increase the proportion of dry matter allocation to grains. Among the yield components, seed size ($R^2$=0.98), number of grains pod$^{-1}$ ($R^2$=0.70) and number of pods plant$^{-1}$ ($R^2$=0.68) showed a highly significant (P<0.01) positive association with grain yield (Table 1). Combined contribution of number of seeds pod$^{-1}$, seed size and number of pods plant$^{-1}$ ($R^2$=0.998) or the number of grains pod$^{-1}$ and seed size ($R^2$=0.997) towards grain yield plant$^{-1}$ indicated our primary concern to focus attention to improve the seed size of these legumes under rainfed conditions to improve harvest index in these legumes.

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