

Manifestation of Heterosis in Growth and Development of Hybrid 1 (Pearl millet) with Particular Reference to Relative Growth Rate, Leaf Area and Dry Matter Production*

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Introduction: That heterosis is a genetic phenomenon cannot be doubted. Recently many have however, studied the specific physiological-biochemical reactions and mechanisms responsible for the superior growth and development in the hybrids of various crops. For studying these specific reactions responsible for hybrid vigour, attention should be focussed on the actual stage at which the heterosis is manifested in growth and the degree of its manifestation. The study of relative growth rate, leaf area and dry matter accumulation are interesting fields for understanding the phenomenon of heterosis and the stage of manifestation of hybrid vigour.

Ashby (1930, 1932, 1937) based on his work on corn and tomato, emphasised that heterosis was due to the maintenance of an initial advantage in embryo size and not due to the high relative growth rate. The hypothesis was questioned by Sprague (1953), East (1936), Kempton and McLane (1942) and Whaley *et al.* (1950). They concluded that embryo size was of little importance in the expression of heterosis. Lunderstorm (1935), Whaley (1962), Sarkissian *et al.* (1964) and Renganathan and Rachie (1967) showed that heterosis was due to higher growth rates at least in the early stages of the growth, and in some cases heterosis occurred in later stages of growth. Hatcher (1940) observed in tomato a significant heterosis for growth rate after flowering stage. Whaley *et al.* (1950), found significant heterosis in total dry matter accumulation and leaf area at all stages of the corn hybrids. In bajra hybrids, Ahluwalia *et al.* (1962) and Burton (1968) reported hybrid vigour for dry matter yield resulting in higher yield of grains.

Materials and Methods: A population of two parents (Bil 3 B and Tf 23 A) and the hybrid (HB 1) was raised under uniform field conditions and cultivation practices, in randomised block design with seven replications. For calculating growth rates, the sampling was done at four stages of duration of the crop, 20, 40, 60 and 80th day. Seven plants in each variety, one in each replication, were dug out, sized and dried in hot air oven at 90°C for 24 hours. The dry weight of the whole plants and that of leaves alone, were recorded separately.

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Relative growth rate was calculated per unit plant weight using the formula of Blackman

$$r = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

where W_1 is the initial dry weight and W_2 is the final dry weight, $(t_2 - t_1)$ is the sampling intervals in days and 'r' is the relative growth rate for dry matter production.

The total dry matter accumulation, was observed at ten day interval upto 80th day. Leaf area of the plant was measured from 30th day upto harvest at ten day interval. In earlier stages, planimeter method was used and in later stages the leaf area was measured by using the relationship between the known area and dry weight of the leaves.

Results: Embryo size: The dry weight of hundred excised embryos of hybrid seeds does not show an initial advantage.

TABLE 1. *Weight of hundred seeds, embryos and endosperms of hybrids and the parents expressed in mg*

Parents and hybrid	Seed weight	Embryo weight	Endosperm weight
Bil 3 B	666.8	21.8	645.0
Tf 23 A	568.8	18.8	550.0
HB 1	599.1	19.1	580.0

Relative growth rate for dry matter production: The RGR studied in HB-1 and its parents at four stages, clearly indicated that hybrid vigour was not exhibited in the seedling stage. The hybrid showed greater growth rate in the second and third stages. There was a significantly high growth rate between 20 to 40 day *i. e.*, during active tillering stage.

TABLE 2. *Relative growth rates of HB1 and the parents in g/day*

Parents and the hybrid	1	2	3	4	Stages
	0-20	20-40	40-60	60-80 days	
Bil 3 B	0.038	0.052	0.050	0.010	
Tf 23 A	0.031	0.052	0.050	0.016	
HB 1	0.034	0.058	0.056	0.016	
Significance of F value	No	Yes	No	No	
C.D. at 1% level	—	0.013	—	—	

Total dry matter production: Total dry matter accumulation showed again clearly that the hybrid did not exceed its parents in total dry weight upto 20th day. The male parent Bil 3 B had more dry weight, but subsequently

between 20-60 days, the accumulation of dry matter at a greater rate than the parents was evident in the hybrid. At harvest stage an average hybrid plant weighed 181.6 g, which was 65.5% more than the better seed parent.

TABLE 3. Total dry matter production in HB 1 and in parents g/plant

Parents and the hybrid	1 10	2 20	3 30	4 40	5 50	6 60	7 70	8 80	States days
Bil 3	0.019	0.63	1.34	6.10	30.04	64.71	88.94	102.5	
Tf 23 A	0.010	0.41	0.87	4.85	19.87	56.60	89.04	109.9	
HB 1	0.015	0.58	1.61	8.17	34.73	101.8	143.86	181.6	
Significance of 'F' value	—	No	—	Yes	—	Yes	—	Yes	
C.D. at 1% level	—	—	—	1.15	—	13.42	—	10.24	

Leaf area: Total leaf area of the plant studied at six stages of plant growth from 30th to 80th day, had shown a progressive increase upto 70th day, both in hybrid and its parents. HB-1 always maintained a large area of leaves.

TABLE 4. Leaf area of the hybrid and its parents at six stages in sq cm

Parents and hybrids	30	40	50	60	70	80	days
Bil 3 B	280	972	2040	2911	3038	2724	
Tf 23 A	234	748	1877	2579	3629	3482	
HB 1	363	1223	2673	4579	5181	4714	
Significance of 'F' value	—	yes	—	yes	—	yes	
C.D. at 1% level	—	147.61	—	1606.0	—	759.1	

Discussion: The results of seed size and embryo weight indicated that embryo or seed size was not the determining factor for the final size of HB-1 plants. The study of growth rates at various stages of crop growth had shown that a significant heterosis was manifested in HB-1 only in the mid and later stages of crop growth but not in seedling stage as reported by Sprague (1953), Whaley (1952), Sarkissian (1964) in corn and Renganathan and Rachie (1967) in sorghum. HB-1 showed high growth rate between 20 and 60 days. The RGR was significant between 20 and 40 days, the stage during which tillering took place, thus resulting in increased number of tillers and leaves. Thus the manifestation of vigour starts in HB-1 at the beginning of tillering stage. The high growth rates in the mid and later stages of crop growth were also reported by Lunderstrom (1935), Hatcher (1940), Whaley *et al.*, (1950) in corn and tomato. The superior growth rate in HB-1 was further evident from the total dry matter accumulation at these stages. During early seedling stage between 0 and 20 days the dry weight of the hybrid plant was inferior to

the vigorous male parent Bil 3 B. A progressive heterosis in respect of this character was observed only after 20th day in IIB-1 and at harvesting stage. IIB-1 showed 65.5 per cent more dry matter than the superior parent.

The total leaf area studied at all stages of the hybrid showed its heterotic vigour from the early tillering stage. The photosynthetic surface is of great importance to the plants and is closely correlated to maximum synthesis and accumulation of dry matter. This is one of the advantages attributed to HB-1 plant. Subsequent studies of the senior author (1969) unpublished had shown that this was true in HB-1 not only with regard to the total photosynthetic surface but also to its efficiency, to assimilate carbondioxide.

The superior growth rate observed at tillering stage of the crop growth was of economic advantage for suggesting the split application of a major portion of nutrients in the form of top dressing to boost the growth. Application of nitrogenous fertiliser at the beginning of tillering stage (20-25 days) will be more beneficial for the hybrid, during which stage only the hybrid actually starts manifesting its hybrid vigour.

Summary: Relative growth rate, total dry matter accumulation and leaf area, under different stages of the growth of HB-1 and its parents, were studied under field conditions in randomised block design. The HB-1 showed its superiority in all these three factors but very high growth rate was manifested only after twenty days of the growth in the hybrid. At seedling stage the heterotic vigour was absent in HB-1. After seedling stage the dry matter accumulation and leaf area showed a progressive significant increase which was greater in hybrids than its parents. The increased photosynthetic surface is one of the advantages attributed to HB-1. The manifestation of heterosis at the tillering stage of the crop, suggests that the crop needs greater cultural attention between 20 to 25 days.

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