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Stay Green Trait as Influenced by Nitrogen Level on Dry Mater Accumulation and Distribution in Rabi Sorghum Genotypes

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Abstract: *Sorghum [Sorghum bicolor (L,) Moench] hybrids containing the stay-green trait retain more photosynthetically active leaves under drought than do hybrids that do not contain this trait. Since the Longevity and photosynthetic capacity of a leaf are related to its N status, it is important to clarify the role of N in extending leaf greenness in stay-green genotypess. A field experiment was conducted during 2006-07 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad to access rabi sorghum genotypes for their stay green trait, yield and yield components under varied nitrogen levels. The four genotypes M35-1, DSV-4, RSLG-272 and E-36-1 were used for the interaction study along with the varied nitrogen treatments. Genotypic differences in response to the nitrogen level wereexplained by differences biomass accumulation during 50 per cent flowering, 15, 30 days after flowering (DAF) and at harvest.*

1. INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is the fourth important cereal in the world next to wheat, rice and maize. It is an important crop and staple food of millions of people in the semi-arid and arid tropics of Africa and Asia. In semiarid and arid tropics, the rainfall is low and highly erratic leading to drought. Drought is a major constraint specifically at terminal stages of crops to agricultural production. Among the cereals sorghum is considered as one of the drought tolerant crops.

Among the various drought tolerance parameters, more recently “stay green”, as a secondary trait has been identified in sorghum, which is very much associated with post anthesis drought tolerance. Stay green, as a trait of post anthesis drought tolerance retain leaves in an active photosynthetic state when subjected to water stress conditions during grain filling period. Maintenance of higher green leaf area at maturity is an excellent indicator of stay green trait. Nitrogen is a crucial component of plant nutrition, and its deficiency limits productivity of crops more than any other element. Higher N levels led to higher leaf chlorophyll index and staygreen in sorghum during anthesis[1], previous research has demonstrated that application of N increased biomass and grain yield of sorghum [2, 3]. Greater yields and components of yields with increases in N application were also observed in maize (*Zea mays* L.) and wheat (*Triticumaestivum*).

Despite large genetic variability in grain sorghum for grain yield, little research has been done on the responses of various genotypes or hybrids to N, particularly on the influence of N on various physiological and yield traits.Enhanced understanding of genetic and physiological characteristics of sorghum genotypes, their responses to N, and associations among various traits is needed. We hypothesize that there are differences in physiological and yield traits among grain sorghum genotypes in response to N. The objectives of this study were to determine the responses of sorghum genotypes to N fertilizer and the relationship with biomass accumulation.

2. MATERIALS AND METHODS

A field experiment was conducted during rabi 2006-07 to assess rabi sorghum genotypes for their stay green trait under various nitrogen levels applied and its impact of stay green trait on biomass accumulation. The present study was carried out with four elite genotypes (M 35-1, DSV-4, RSLG-272 and E-36-1) allotted in a sub plots on five nitrogen levels as a main plots in three replications. The nitrogen levels were as follows:

1) N_o–No nitrogen
2) N_1–100% RDN (Recommended dose of nitrogen) as basal
3) N_2–100% RDN (50% basal + 50% top dressing)
4) N_3–150% RDN as basal
5) N_4–150% RDN (100% basal + 50% top dressing). Top dressing was carried out an 45th days after sowing.

The genotypes were obtained from Principal Investigator (Breeding), All India Co-ordinated Sorghum Improvement

Project, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad.

Sowing was done by hand dibbling seeds in furrows at a distance of 45 cm between the rows and 15 cm between the plants. Nitrogen was applied as per the treatments, at basal and top dressing. Complete care was taken to control pests and diseases during the crop growth period. The crop was harvested as and when the genotypes attained physiological maturity.

The observations were confined to only terminal stages i.e. after 50%, flowering to harvest as the stay green trait was very much associated with grain filling to harvest stage only. The details of observation taken and standard procedures were adopted

3. DRY MATTER PRODUCTION AND ITS DISTRIBUTION

Three randomly selected plants were used to record the dry matter production and its distribution in different parts at various growth stages. The sampled plants were separated into leaves, stem and panicle and dried in an oven at 80°C until a constant weight was attained. Dry weight was recorded separately at 50 per cent flowering, 15 days after 50 per cent flowering, 30 days after 50 per cent flowering and at harvest to assess dry matter accumulation in different parts. Total dry matter was calculated by adding the dry weight of different plant parts and expressed as grams per plant.

4. RESULT AND DISCUSSION

4.1 Dry matter accumulation and distribution

The results obtained on dry matter accumulation and its distribution in leaf, stem, panicle and total dry matter during the growth as influenced by different nitrogen levels, genotypes and their interactions at different growth stages are presented in Table 1 and 2.

4.2 Leaf dry weight (g plant $^{-1}$)

It was observed from the results that the leaf dry weight increased from 50% flowering to 30 days after 50% flowering and thereafter there was a continuous decrease in leaf dry weight till harvest. At all the stages, the leaf dry weight under different nitrogen levels differed significantly.

Among the genotypes, RSLG–262 has maintained significantly higher leaf dry weight at 50% flowering and 15 days after flowering (DAF) (21.54 and 23.85, respectively) followed by DSV-4, which recorded significantly maximum leaf dry weight (21.18 and 22.95, respectively). While E–36-1 recorded minimum leaf dry weight at all the stages, except at harvest (18.2, 16.79, and 12.31, respectively) followed by M–35-1 (19.10, 21.18 and 16.33, respectively) at 50% flowering to 30 DAF. The earlier studies suggest thatdry matter accumulated during pre-flowering contributed only 12% to the grain yield and about 93% is due to assimilation by the upper four leaves and remobilization of stem reserves after anthesis[4].Further, [5] observed that increase in total dry matter till the maturity, but the dry matter in leaves decreased from milky to ripening stage in proportion to the accumulation of dry matter in earhead indicating actual translocation of assimilates during grain filling. Interaction effects between nitrogen levels and genotypes differed significantly at all the stages.

4.2 Stem dry weight (g plant $^{-1}$)

Similar to leaf dry weight stem dry weight also increased from 50% flowering to 15 days after flowering and thereafter it declined till maturity. The nitrogen levels, genotypes and their interactions differed significantly all the growth stages (50% flowering, 15 DAF, 30 DAF and at harvest), except the nitrogen levels did not differ significantly at 50% flowering and 30 DAF.Among the genotypes, DSV-4 recorded significantly higher stem dry weight (36.62) at 50% flowering, which was on par with M–35–1 and RSLG–262 (35.73 and 35.35, respectively). This indicates genotypic differences for dry matter accumulation and their efficiency in maintaining the dry matter.Among the interaction effects, RSLG-262 with nitrogen applied @ 150% RDN (100% basal + 50% top dressing) and 150% RDN as basal recorded significantly higher stem dry weight (43.76 and 44.45, respectively) at both 50% flowering and 15 DAF.

Table 1: Effect of different nitrogen levels on dry matter accumulation in leaf, stem and panicle at different stages (50% flowering and 15 DAF) in rabi sorghum genotypes

Treatments	50 % flowering				15DAF			
	Leaf	Stem	Panicle	Total	Leaf	Stem	Panicle	Total
Nitrogen levels								
N0	20.19ab	30.80	11.23bc	61.38b	21.38ab	29.93c	20.76	84.06b
N1	19.89ab	32.48	10.68c	63.41b	22.76a	33.28abc	21.31	88.80a
N2	18.42b	33.09	12.52ab	63.74b	20.28b	32.24bc	20.36	88.94a
N3	21.75a	32.57	11.58abc	67.88a	19.97b	36.67a	20.59	91.06a
N4	19.95ab	35.36	12.97a	68.37a	21.55ab	34.95ab	20.08	91.22a
Mean	20.03	32.86	11.79	64.95	21.18	33.41	20.62	88.81
LSD at 5%	2.48	NS	1.35	2.89	1.81	3.48	NS	3.14

Genotypes								
V1-M 35-1	19.10ab	35.73a	11.18bc	66.26b	21.18b	35.58a	17.54b	90.66b
V2–DSV4	21.18a	36.62a	12.77 a	70.13a	22.95ab	34.81a	23.22a	92.00b
V3–RSLG-262	21.54a	35.35a	10.83 c	70.57a	23.85a	37.26a	17.85b	95.38a
V4–E-36-1	18.32b	23.74b	12.41ab	52.86c	16.79C	26.31b	24.81a	77.22c
Mean	20.03	32.86	11.79	64.95	21.19	33.49	20.85	88.81
LSD at 5%	2.48	8.32	1.35	2.89	1.87	3.49	1.70	3.14
Interactions (NxV)								
N0V1	17.39gh	34.56a-d	10.50f-h	62.43g	26.54a	31.22e-g	16.48fg	88.17c
N0V2	24.61b	33.20bcd	11.48ef	69.30d	21.62def	33.28d-f	24.38b	93.71b
N0V3	23.48bcd	33.77b-d	11.83def	65.78ef	16.84bcd	34.69de	18.14eg	87.73c
N0V4	15.23h	21.67e	11.11eg	48.00if	23.43bcd	20.52i	24.03b	66.63g
N1V1	20.86def	32.66b-d	9.89gh	63.41fg	25.40ab	33.47d-f	15.93g	88.22c
N1V2	23.69bc	39.09ab	11.44ef	74.01b	26.49a	41.60ab	24.37b	99.68a
N1V3	20.42ef	32.37b-d	9.83gh	68.57de	15.73f	31.44e-g	18.52e	92.19b
N1V4	14.59h	25.78de	11.55def	47.56j	19.80fgh	26.61hi	26.43a	75.09f
N2V1	16.96gh	35.55abc	11.64def	64.05fg	24.45bc	36.71cd	18.45e	91.19bc
N2V2	21.56c-f	36.22abc	13.53abc	71.60b-d	21.32efg	30.68e-g	23.60bc	91.09bc
N2V3	20.50ef	31.90bcd	12.51cde	68.66de	15.57j	36.63cd	15.32g	94.26b
N2V4	14.65h	28.58cde	12.42cde	50.65i	19.58fgh	24.87i	24.08b	79.21e
N3V1	18.75fg	37.22abc	11.43ef	68.73de	18.66hi	38.67bc	18.49e	92.87b
N3V2	16.88gh	38.19abc	13.11bcd	65.66ef	25.37ab	34.52de	22.02cd	87.90c
N3V3	20.66ef	34.84a-d	9.50h	72.79bc	16.00i	44.45a	16.52fg	102.40a
N3V4	30.69a	20.01e	12.30cde	64.35fg	16.28i	29.04gh	25.33ab	81.11de
N4V1	21.55e-f	38.65ab	12.43cde	72.66b	22.59cde	36.32cd	18.36e	92.85b
N4V2	19.16fg	36.39abc	14.30ab	70.10cd	19.68fgh	33.98def	21.71d	87.61c
N4V3	22.65b-e	43.76a	10.47igh	76.94a	24.42bc	39.01bc	15.71g	99.00a
N4V4	16.43gh	22.64b	14.68a	53.76h	19.51gh	30.47bg	24.49b	84.04d
Mean	20.29	33.00	11.93	65.65	20.83	33.86	20.61	89.19
LSD at 5%	2.48	8.32	1.35	2.89	1.87	3.48	1.70	3.14

Means followed by same letter did not differ significantly by DMRT (p=0.05) NS : Non significant

Note :N_0-No nitrogen N_1–100% RDN as basal N_2–100% RDN (50% basal + 50% top dressing) N_3–150% RDN as basal N_4–150% RDN (100% basal + 50% top dressing)

Table 2: Effect of different nitrogen levels on dry matter accumulation in leaf, stem and panicle at different stages (30 DAF and harvest) in rabi sorghum genotypes

Treatments	30 DAF				Harvest			
	Leaf	Stem	Panicle	Total	Leaf	Stem	Panicle	Total
Nitrogen levels								
N0	14.79b	57.68	49.67b	122.2b	12.51b	46.99b	84.89c	144.2c
N1	17.21a	60.34	55.75a	133.5a	14.62ab	52.24a	89.65b	156.7b
N2	13.71b	58.58	50.10b	122.2b	14.94ab	50.94a	92.35b	158.2b
N3	16.96a	61.53	57.06a	135.4a	15.34ab	52.44a	101.96a	169.8a
N4	18.38a	61.30	56.58a	136.3a	15.91a	52.65a	104.28a	172.9a
Mean	16.21	59.88	53.83	129.92	14.66	51.05	94.62	160.37
LSD at 5%	1.75	NS	3.64	4.97	2.717	3.85	2.99	5.56
Genotypes								
V1-M 35-1	16.33b	63.14ab	55.06a	134.0a	14.14	55.70B	91.53c	161.9c
V2–DSV4	18.27a	64.35a	55.61a	138.9a	15.80	60.67a	104.17a	180.9A
V3–RSLG-262	17.93ab	59.56ab	54.78a	137.8a	15.26	58.53ab	96.78b	169.8B
V4–E-36-1	12.31c	52.49b	49.88b	108.9b	13.47	29.31c	86.01d	128.8D
Mean	16.21	59.88	53.83	129.9	14.66	51.05	94.62	160.35
LSD at 5%	1.75	10.83	3.643	4.98	NS	3.85	2.99	5.56
Interactions (NxV)								
N0V1	15.40ef	61.57a-d	50.37fg	127.7ef	12.61ef	52.42e	82.44i	147.8h
N0V2	16.37de	64.33ab	50.82efg	131.7dc	13.65c-f	56.00de	90.98f	159.6ef
N0V3	15.68de	59.42a-d	50.43bg	125.8f	12.81df	54.00de	85.75h	152.5gh
N0V4	11.71h	45.40e	47.05gh	103.5i	10.99f	25.53g	80.37i	116.7k

N1V1	17.54cd	61.35a-d	57.28abc	136.4cd	13.69b-f	63.26b	87.70gh	165de
N1V2	19.54ab	67.22a	58.44ab	143.7ab	15.55a-c	57.64cd	99.33fg	172.9c
N1V3	19.37abc	62.55a-d	54.67b-c	144.6a	14.67a-e	58.32cd	91.18f	164.2de
N1V4	12.39gh	50.23de	52.60def	109.6h	14.59a-e	29.73f	80.39i	127.7i
N2V1	12.57gh	63.54abc	49.52fg	130.8ef	14.69a-e	52.73e	90.55f	157.8fg
N2V2	16.29de	62.55a-d	53.55e-f	132.7de	15.63a-e	63.75b	104.65c	184.1b
N2V3	14.63ef	57.14a-e	53.62ef	99.48i	15.97a-d	57.64cd	93.45ef	167.1cd
N2V4	11.34h	51.08cde	43.70h	138.5bc	13.55c-f	29.66de	80.74i	123.9i
N3V1	17.51cd	65.70ab	58.48ab	144.8a	14.84a-e	55.59de	98.29d	168.7cd
N3V2	18.47bc	61.17a-d	58.57ab	143.5ab	16.63abc	61.61bc	112.53a	192.6a
N3V3	19.41abc	53.70b-e	58.65ab	114.7g	15.92a-d	61.09bc	104.46c	179.8b
N3V4	12.45gh	65.57ab	52.54def	144.0a-c	13.97b-f	31.45f	92.55f	138i
N4V1	18.63bc	63.55abc	59.63a	141.8a-c	14.95a-e	54.51de	98.65d	170.1cd
N4V2	20.65a	66.48ab	56.66a-d	143.5ab	17.52a	64.36a	113.38a	195.2a
N4V3	20.36ab	65.00ab	56.52a-d	142.6ab	16.94ab	61.58bc	109.07b	185.6b
N4V4	13.66fg	50.17de	53.52c-f	117.4g	14.23b-e	30.16f	96.00dc	140.8i
Mean	16.53	60.09	54.46	132.44	14.91	51.12	96.44	163.0
LSD at 5%	1.75	10.83	3.643	5.00	2.72	3.85	2.99	5.56

Means followed by same letter did not differ significantly by DMRT (p=0.05) NS : Non significant

Note: N_0-No nitrogen N_1–100% RDN as basal N_2–100% RDN (50% basal + 50% top dressing) N_3–150% RDN as basal N_4–150% RDN (100% basal + 50% top dressing)

On the other hand remobilization of stem reserves to ear head was less in these stay green genotypes. This was also in conformity with [6]. In another study genotypes maintained higher dry matter in leaves, stem and peduncle during post anthesis period and decreased sharply as the crop approached maturity [7]. This indicates that the remobilization of stem reserves during post anthesis period to developing grains is important for higher productivity.

Panicle dry weight (g plant^{-1})

Panicle dry weight (g plant^{-1}) differed significantly with respect genotypes, nitrogen levels and their interactions at all the stages, except nitrogen level did not differ significantly at 15 days after flowering. Among the nitrogen levels, nitrogen applied @ 150% RDN (100% basal + 50% top dressing) significantly recorded highest panicle dry weight (12.97) at 50% flowering followed by nitrogen applied @ 100% RDN (50% basal + 50% top dressing) recorded higher panicle dry weight (12.52). Among the genotypes at 50% flowering stage, DSV-4 recorded significantly higher panicle dry weight (12.77) followed by E-36-1 (12.41). At 30 DAF and harvest. Genotype DSV-4 recorded significantly higher panicle dry weight (55.61 and 104.17, respectively) when compared to other genotypes at both the stages. The genotype, RSLG-262 recorded higher panicle dry weight (96.78) at harvest. Among the interaction effects, the genotype E-36-1 with the nitrogen applied @ 150% RDN (100% basal + 50% top dressing) and 100% RDN as basal, recorded significantly highest panicle dry weight (14.68 and 26.43, respectively) at 50% flowering and 15 DAF. The genotype M-35-1 (59.63) and DSV-4 (113.38) recorded significantly maximum panicle dry weight with nitrogen applied @ 150% RDN (100% basal and 50% top dressing) at both 30 DAF and harvest.

Total dry weight (g plant^{-1})

The result obtained on total dry weight per plant at different stages indicated that, nitrogen level, genotypes and their interaction effects differed significantly at all the stages of growth from 50% flowering to harvest at an interval of 15 days. In general, the total dry weight showed an increasing trend from 50% flowering to harvest.

At all the four stages, the nitrogen applied @ 150% RDN (100% basal + 50% top dressing) recorded higher total dry weight (68.37, 91.22, 136.3 and 172.9, respectively), which was on par with 150% RDN as a basal (67.88. 91.06, 135.4 and 169.8, respectively).

Among the genotypes, RSLG-262 recorded significantly higher total dry weight (70.57 and 95.38, respectively) at both 50% flowering and 15 DAF, which was on par with DSV-4 (70.13 and 92.00, respectively) at both stages. The genotype, DSV-4 recorded significantly higher total dry weight (138.9 and 180.90, respectively), which was on par with the genotype M-35-1 (134.00) and RSLG-262 (137.8) at 30 DAF only. However the genotype RSLG-262 recorded significantly higher total dry weight (169.8) at harvest. Tall and late maturating sorghum genotypes accumulate more dry matter in vegetative parts [8].Varietal differences in dry matter accumulation was observed between the flag leaf emergence and anthesis and next higher values were between anthesis to dough stage [9].

Among the interaction effects the genotypes RSLG-262 with nitrogen applied @ 150% RDN (100% basal + 50% top dressing) recorded significantly higher total dry weight (70.94 and 99.00, respectively) at both 50% flowering and 15 DAF.

At 30 DAF the interaction effects between the genotype M-35-1 and nitrogen applied @ 150% RDN as basal recorded significantly higher total dry weight (144.80). The genotype DSV-4 with nitrogen applied @ 150% RDN (100% basal + 50% top dressing) recorded significantly higher total dry weight (195.2) at harvest.

5. CONCLUSION

Nitrogen levels and their interaction differed significantly for total dry matter at all the stages. At harvest the genotype DSV-4 recorded maximum leaf, stem, panicle and total dry matter at all the stages, followed by RSLG-262 and M-35-1, these genotypes yielded high and the genotype E-36-1 accumulated lesser dry matter and yielded moderate.

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