GENETIC VARIABILITY AND PATH COEFFICIENT STUDIES ON FODDER YIELD AND ITS COMPONENTS IN OATS

(*Avena sativa*. L.)

P. SUKUMARAN NAIR

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THESIS

Submitted to the University of Udaipur in the partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

[PLANT BREEDING AND GENETICS]

Department of Agricultural Botany, Rajasthan College of Agriculture,
UNIVERSITY OF UDAIPUR,
UDAIPUR.

GENETIC VARIABILITY AND PATH COEFFICIENT STUDIES ON FODDER YIELD AND ITS COMPONENTS IN OATS (*Avena sativa* L.)

A Thesis
Presented to
the Faculty of Agriculture
University of Udaipur

In Partial Fulfilment
of the Requirements for the Degree
of
Master of Science in Agriculture

By
P. SUKUMARAN NAIR
July, 1976.

Comments on thesis entitled GENETIC VARIABILITY & PATH-COEFFICIENT STUDIES ON FODDER YIELD AND ITS COMPONENTS IN OATS (Avena Sativa L.) submitted by Mr P Sukumaran Nair to the University of Udaipur

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Thesis embodies results on heritability, genetic advances, correlations and path-coefficients in forage oats. Study is based on 32 genotypes of oats. Component characters of both green and dry matter yield have been studied and path-coefficient analysis based on first order and second order components has revealed an interesting information regarding the most important characters like plant hight, the numbers of tillers, leaf area and the number of leaves. Their direct effects on green weight of both the leaves and stem are high and maximum influence was found to be of the leaf area. This is an important confirmation of the recent finding in forages, including oats, that the leaf attributes are relatively more important component characters of both green and dry matter yield and, therefore, could be used as selection criteria for further genetic improvement.

Thesis is well-written and the review of literature is up-to-date. Research methodology, including statistical analysis is appropriate. I, therefore, strongly recommend the thesis for the award of the said degree as the work done by the author is of good standard.

Sd/-

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CERTIFICATE I

Dated 19th July, 1976.

THIS IS TO CERTIFY THAT Mr. P. SUKUMARAN NAIR HAS SUCCESSFULLY COMPLETED THE COMPREHENSIVE EXAMINATION HELD ON 19th June, 1976 AS REQUIRED UNDER THE REGULATIONS FOR MASTER OF SCIENCE IN AGRICULTURE.

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CERTIFICATE II

Dated 19th July, 1976.

THIS IS TO CERTIFY THAT THIS THESIS ENTITLED "GENETIC VARIABILITY AND PATH COEFFICIENT STUDIES ON FODDER YIELD AND ITS COMPONENTS IN OATS (*Avena sativa* L.)" SUBMITTED FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE IN THE SUBJECT OF PLANT BREEDING AND GENETICS OF THE UNIVERSITY OF UDAIPUR IS A BONAFIDE RESEARCH WORK CARRIED OUT BY Mr. P. SUKUMARAN NAIR UNDER MY SUPERVISION AND THAT NO PART OF THIS THESIS HAS BEEN SUBMITTED FOR ANY OTHER DEGREE. THE ASSISTANCE AND HELP RECEIVED DURING THE COURSE OF INVESTIGATION HAVE BEEN FULLY ACKNOWLEDGED.

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CERTIFICATE III

Dated 21.9., 1976.

THIS IS TO CERTIFY THAT THE THESIS ENTITLED "GENETIC VARIABILITY AND PATH COEFFICIENT STUDIES ON FODDER YIELD AND ITS COMPONENTS IN OATS (*Avena sativa* L.)" SUBMITTED BY Mr. P. SUKUMARAN NAIR TO THE UNIVERSITY OF UDAIPUR IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE IN THE SUBJECT OF PLANT BREEDING AND GENETICS HAS BEEN APPROVED BY THE STUDENT'S ADVISORY COMMITTEE AFTER EVALUATION BY THE EXTERNAL EXAMINER AND AN ORAL EXAMINATION BY THE COMMITTEE.

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Udaipur
Dated 19th July, 1976.

(P.SUKUMARAN NAIR)

C O N T E N T S

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INTRODUCTION

The ruminants are able to produce high food in animal protein and other nutrients for man from substances which are inedible and cannot be converted in to human food to any appreciable amount. The principal source of energy to convert the ruminal end products needed for meat, milk and wool are volatile fatty acids and lactic acids, which are produced in and absorbed from the rumen. All these are made available from cereals and legumes, which are the major food for cattle. According to Kirk et al. (1934) oats are more palatable, and stands first among the cereals like barley, wheat and rye.

India has the largest cattle population in the world. With the increase in cattle population the supply of fodder for domestic animals is getting more and more deficient every year. In most of the regions of our country, cereal straw is provided as cattle feed. The present trend towards the development of dwarf varieties of cereals make a decrease in the production of fodder for livestock. Hence it is obvious that adequate steps are to be taken in good time to augment the fodder resources of the country.

In India crops are seldom grown as fodder crops except in some limitted area. However oats as fodder is cultivated in Western U.P., Pünjab and a little area in Maharshtra.

Oats belong to the family graminae and under genus *Avena* . "The origin of the plant is unknown but it is believed to be somewhere in north west of Alps and on the border of Europe towards Tartary and Caucasses" (George Watt, 1889).

Oats are suited to all types of soils and grown in *rabi* season. It requires cool climate. No inter-culture is usually done. Irrigation and manure is also less when compared to other crops.

The annual fodder production in our country is only 111 M. tonnes, against an estimated requirement of 239 M. tonnes (1969)*. Therefore, the development of high yielding fodders is very essential to cope up with the increasing demands.

Before planning any breeding scheme, aimed at the improvement of a complex character like fodder yield which is influenced not only by the genetical architecture of a plant but by environment also to a

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* Handbook of Agriculture, I.C.A.R., New Delhi.

great extent, it becomes very essential to find out its (yield) component characters and their extent of association. Simple correlation studies alone ~~also~~ does not projects the true causal relationship between the two characters and hence their partition into direct and indirect effects is indispensable.

It was with this view in mind ~~that~~ the present piece of work on oats was under taken to estimate the various genetical parameters like heritability, genetic coefficient of variation, genetic advance and genetic gain; components of forage yield and their extent of association and path analysis to work out their direct and indirect effects.

In oats maturity is a major factor for the assessment of fodder value (Mayer et al. 1957). The yield and maturity are related to each other (Kaufman, 1961). The percentage of organic and inorganic substances like, fat, ash etc. are decreasing with maturity (Smith Dale, 1960) as well as palatability also is decreased (Schmidt, 1963). The plant height is another important criterion for forage oats (Noller et al. 1959 and Anderson, 1963). The manner in which light is distributed within a plant community is influencing the dry matter accumulatioon (Pearce et al. 1957). The factors involving light distribution are leaf area and leaf angle (Tanner et al., 1966).

The percentage of leaf by weight is also an important criterion for selection and development of forage oats (Kilcher and Troelsen, 1973). There will be variation in forage yield due to height of the plant and tiller number (Bohra et al. 1973). Changes in protein content is related to heading date (Campbell and Frey, 1974). Green weight, total dry weight and percentage dry weight are the other parameters of potentiality of the forage value of cereals (Fisher and Fowler, 1974) and hence the characters like, days to emergence of flage leaf, days to maturity, plant height, number of tillers, number of leaves, leaf angle, leaf area, green weight of stem, green weight of leaves, total green yield, stem/leaf ratio, total dry matter yield, per cent dry weight, per cent crude protein and per cent ash content were selected for the present investigation.

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REVIEW OF LITERATURE

The following are the pioneers in the field of study related to the present investigations.

<u>Genetic variability, Heritability, Expected genetic advance, Genetic gain and Genetic coefficient of variation</u>.

Fisher (1918) partitioned genetic variance in to its components as additive genetic variance, dominant components and epistatic components. According to him the additive genetic variance can be exploited for genetic advance through selection.

According to Panse (1957), if heretability is mainly due to genetic effects (dominance and epistasis) the genetic gain would be low while in other cases heritability is chiefly due to the additive gene effects; a high genetic advance may be expected.

Petr *et al*. (1966) estimated genotypic correlations, dominance and heritability of quantitative characters in oats. Plant height, panicle length, heading date, number of spikelets per panicle, number of panicles per plant and grain yield had 61, 54, 87, 74, 33 and 53 per cent heritability respectively in a six parent diallel of 15 oat crosses.

Moore and Edwards (1968) in the estimation of genetic variance in oats for heading date, straw strength, plant height, panicle number, number of seeds per panicle and seed weight found that the characters were significantly differing from zero at 5 per cent level in three F_3 and F_4 population. Genetic variance estimations were reduced from 40 to 90 per cent for most characters, when genotypic environment interactions were removed. Heading date was the most stable character studied.

Bhagmal et al. (1970) found plant height was the most variable character among the nine quantitative characters studied in fodder oats. Heritability estimates were moderate for plant height and fodder yield and high for tiller number, stem girth, number of leaves on the best developed tiller, leaf length, leaf breadth, leaf stem ratio and half bloom stage.

Muehlbauer et al. (1971) estimated heritability of maturity, plant height and straw strength in oats and found that the values were 60.7, 39.7 and 20.0 per cent respectively.

Phul et al. (1972) investigated the inheritance of six forage characters among 40 genotypes of oats at two localities. Forage yield had the highest genetic coefficient of variation followed by tiller number. Moderately high heritability values were obtained for plant height and leaf breadth at the 1st locality and for tiller number and forage yield at the 2nd locality. High genetic gain could only be predicted for forage yield and tiller number at the second locality. They concluded that selection for high tillering was quite effective to increase fodder yield.

Correlations

Galton's (1889) concept on correlation elaborated by Fisher (1918).

Dent J.W. (1957) found that oat cultivars grown in a single environment at a comparable physiologic stage had similar straw protein contents and also found no relationship between protein contents in straw and grain of cultivated oats.

Gupta, V.P. (1971) reported selection criteria for improving green fodder yield quality in pearl millet. Data on plant characters and chemical constituents of green fodder were utilized to find out the association of chemical characters with morphological characters. Correlations and regression studies revealed that more number of leaves, thin stems and less height and earliness accounted for 87 per cent variation in green fodder protein of Indian varieties, while less number of leaves and low tillering accounted for 50 per cent variation in oxalic acid contents of American inbreds. As leafiness and high tillering favourably influenced the grain yield, it seems feasible to combine good forage quality with high yield. Phosphorus, calcium and ash showed some dependence on plant height and lateness, but the degree of determination was only 5 to 20 per cent.

Suthman, D.D. and Marten, G.C. (1972) measured variation for all quality traits except crude protein concentration in oats. Forage was negatively associated with quality at heading date but independent two weeks later. Forage yield was correlated with plant height (+ 0.67) and heading date (+ 0.76).

Solanki *et al.* (1973) studied the components of green fodder yield in oats and found that the genotypic correlation between plant height and tiller number had the maximum correlation (r = + 0.890) followed by number of tillers with leaf length (r = + 0.801). The height of the plant and leaf length had negative correlation (r = -0.705), but the leaf breadth had high positive relationship (r = +0.798). Though the green yield had a positive correlation with plant height (r = + 0.610) number of tillers (r = + 0.410) and leaf breadth (+ 0.591), there was a negative relationship between green yield and leaf length (r = - 0.408). Tiller number and leaf breadth had comparatively low correlation value (r = +0.201) and they found a negative correlation between leaf breadth and leaf length (r = -0.198). The phenotypic correlation coefficients were lower in all cases except in negative correlations.

Path coefficient analysis

Path coefficient analysis suggested by Wright (1921, 1923, 1934, 1960) and discussed by Niles (1922, 1923) Li, C.C. (1955), Turkey (1954), Kempthorne (1957) and Turner and Stevens (1959) is a means of untangling direct and indirect contributions of various factors in building up a complex correlation. This method is based on the premise that the degree of influence of one variable upon other can be defined in quantitative terms. After the construction of causal diagram, the values had to be assigne to each of the influencing paths. The values assigned to these paths is termed the path coefficients. It is defined as the portion of standard deviation of a dependent variabl if arising as a result of the variation in the independent variable. In order to have a coefficient independent of physical units, path coefficients are expressed in terms of standard deviations of Y on X. Therefore, path coefficient may also be considered as standardised partial regression coefficients.

The reports on path coefficient analysis in crop plant are limited,more over, less attempts have been made in most of the fodder crops.

Dewey and Lu (1959) analysed the path between seed size, spikelet per spike, fertility, plant size and seed yield in wheat grass. They found that fertility had high positive direct effect (+ 1.120) towards seed yield followed by the plant size (direct effect = +0.914). But the fertility had its indirect effect through plant size (-0.608). The indirect effect of seed size, spikelet per spike and plant size through fertility were all negative (-0.790, -0.336, and -0.744 respectively). The fertility had negative correlation with seed size (r = -0.706), spikelet per spike (r = -0.300) and plant size (r = -0.665) and hence the path coefficients also showed negative relationships. They concluded that a favourable relationship (r = +0.525) existed between plant size and seed size and since large plants have forage producing advantages, more emphasis should probably be placed on plant size than on fertility. Because of the negative correlation between fertility and plant size and their high direct effect on seed yield, selection must be based on a compromise between the two traits, if maximum yield have to be obtained.

Koeing and Walter (1966) studied the relationship between stalk diameter, leaf number, leaf area and grain yield of sorghum. They found high positive influence of these characters on grain yield.

Fonseca and Patterson (1968) analysed the path coefficients on wheat revealing that the number of spikes (+ 0.9759) and kernels per spike (+ 0.7182) had the maximum direct effect on yield as against the correlation coefficient positive direct effect (+ 1.120) towards seed yield followed by the plant size (direct effect = +0.914). But the fertility had its indirect effect through plant size (-0.608). The indirect effect of seed size, spikelet per spike and plant size through fertility were all negative (-0.790, -0.336, and -0.744 respectively). The fertility had negative correlation with seed size (r = -0.706), spikelet per spike (r = -0.300) and plant size (r = -0.665) and hence the path coefficients also showed negative relationships. They concluded that a favourable relationship (r = +0.525) existed between plant size and seed size and since large plants have forage producing advantages, more emphasis should probably be placed on plant size than on fertility. Because of the negative correlation between fertility and plant size and their high direct effect on seed yield, selection must be based on a compromise between the two traits, if maximum yield have to be obtained.

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Durate and Adams (1972) analysed the first and second order components of yield in field beans. They took number of pods per plant, number of seeds per pod and seed weight as first order components of the yield. The number of leaflets per plant and size of leaflets were the components of second order, which were immediate causes of variations in the first order yield components. The chief findings were (1) pods per plants exerts a major effect on yield. The direct effect was +0.885.(2) The families where selection had produced divergent types with respect to seed number per pod which had a direct effect of +0.188 and seed weight which had the direct effect of +0.427 respectively. These components also assumed major role in determining yield. (3) Leaf number was highly associated with (direct effect + 0554) pod number per plant and leaf size was highly associated with seed size in families selected for high, moderate and low levels of expression of the two leaf are components. Their interpretations were based on a common genetic programme regulating the number of main stem, internodes and the genetic programme regulating leaf cell number and/or rate of expansion.

Naphade (1972) studied the yield of fodder and other yield contributing characters in 20 sorghum varieties. The yield of fodder showed significant positive correlation with leaf number (r = +0.9268) and plant height (r=+0.6079) at 1 per cent where as the correlation between leaf number and leaf area (r = +0.5246) and leaf nueber and height (r = +0.5146) were positive and significant at 5 per cent. Plant height and leaf area (r = +0.1216) and leaf area and yield (r = +0.3738) were not significantly correlated. In path analysis number of leaves per plant was the most important component of fodder yield, since its direct influence (+0.9127) on yield was the highest, followed by the plant height (+0.1532) and leaf area(+0.1235). So also the plant height had high indirect effect through leaf number (+0.4696). Leaf area through leaf number also was high (+0.4788). He concluded that the number of leaves per plant was the most important contributing factor towards fodder yield.

Phul <u>et al</u>. (1972) studied the genetic variability, correlation and path analysis of fodder yield and its components in 30 varieties of sorghum. They found that the fodder yield showed highest G.C.V. and with number of days to flowering the highest estimate of heritability. The fodder yield was significantly and positively correlated with number of days to flowering, stem girth, the number and length and breadth of leaves. Path coefficient analysis indicated that length and breadth of leaf and stem girth contribute the most towards the fodder yield.

Dahiya (1973) observed in 121 strains of sorghum, that days to 50 per cent flowering, the number of leaves and leaf area had negative direct effect on the green fodder yield and their indirect effect via characters like plant height, stem thickness and dry matter yield were positive; characters like plant height, stem thickness and dry matter yield had high positive direct effect on the green fodder yield.

Patel et al. (1973) analysed the direct and indirect effect of plant height, total leaf area and stalk diameter towards the fodder yield in sorghum. The stalk diameter, plant height and leaf area had r values + 0.839, + 0.622 and - 0.251 respectively as direct effect on fodder yield. The indirect effect of leaf are through plant height was lower but positive (+ 0.336) and the indirect effect of leaf area through stalk diameter was (+ 0.650). The length of internode had direct effect of 0.855 and number of internode had 0.505. They concluded that fodder yield in sorghum is the contribution of plant height, leaf area and length of internode.

Path analysis of fodder yield in Barley was studied by Sharma *et al*. (1973). They included the morphological characters like plant height and tiller per plant along with grain yield and 1000 grain weight. The tiller per plant had a positive direct effect of 0.2809 on fodder yield. It showed slight higher indirect value (+ 0.4429) through 1000 grain weight. The direct effect through plant height and grain yield were negative (-0.0092 and -0.0145). The direct effect of height of plant was very low (+ 0.0749). The direct effect of 1000 grain weight was also positive (+0.3252) but the indirect values through tillers and plant height respectively, were very low and negative.

Solanki, K.R. *et al*. (1973) analysed the path coefficient in 49 genotypes of oats for fodder yield and its components. They obtained the maximum direct influence between green yield and height of the plant (+ 0.441), followed by leaf breadth (+ 0.351). The other two characters, they studied, showed only negligible direct influence as well as negative direct effect; leaf breadth +0.053 and number of tillers -0.100. Even then the indirect effect of tillers via plant height had a value of +0.393, and indirect effect of leaf breadth via plant height was +0.302. The maximum negative value obtained was the indirect effect of leaf length through plant height (-0.312). The other influences were very low and negligible. They concluded that selection on the basis of plant height and leaf breadth simultaneously would be most effective and could lead to further improvement in the forage yield.

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MATERIALS AND METHODS

A field experiment for the analysis of genetic variability and path coefficient studies on fodder yield and its components in oats (*Avena sativa* L.) was conducted during the rabi season in 1975-76.

Experimental site

The experiment was conducted at the fields of Rajasthan College of Agriculture, Udaipur. Udaipur is situated at an altitude of 579.5 M from mean sea level and between 24° north latitude and 75° east longitude.

Lay out of experiment

The experiment was laid out in randomised block design with 4 replications having 32 varieties of oats. Each replication consisted of 32 sub plots, one for each variety, two lines of 4.0 M each length were planted in each sub plot at a distance of 30 cms. Plant to plant distance of 25 cms was maintained by thining.

Seeds and sowing

The seeds of 32 varieties of oats were obtained from the Head, Department of Entomology, Rajasthan College of Agriculture, Udaipur and sowing was done on 19.11.1975.

TABLE 1

Meteriological data for the period from November, 1975 to March, 1976, when the crop was in the field (week wise)

Weeks			Temperature °C.		Humidity (Maximum)	Rainfall (mm.)
			Maximum	Minimum		
5.11.75	-	12.11.75	28.7	10.0	79	-
13.11.75	-	19.11.75	29.5	9.4	76	-
20.11.75	-	26.11.75	28.0	8.3	84	-
27.11.75	-	2.12.75	24.0	5.4	86	-
3.12.75	-	11.12.75	27.0	6.2	80	-
12.12.75	-	16.12.75	27.7	5.6	81	-
17.12.75	-	23.12.75	26.4	5.8	76	-
24.12.75	-	30.12.75	26.6	5.4	79	-
31.12.75	-	6. 1.76	27.9	6.2	61	-
7. 1.76	-	13. 1.76	27.9	7.1	57	-
14. 1.76	-	20. 1.76	24.5	7.2	78	0.5
21.1. 76	-	27. 1.76	25.5	5.8	84	-
28. 1.76	-	3. 2.76	20.0	6.0	79	-
4. 2.76	-	10. 2.76	24.0	6.3	52	6.5
11. 2.76	-	17. 2.76	26.0	10.5	62	-
18. 2.76	-	24. 2.76	28.3	7.6	89	-
25. 2.76	-	3. 3.76	30.6	7.2	79	-
4. 3.76	-	10. 3.76	28.0	11.0	61	-
11. 3.76	-	17. 3.76	31.5	12.5	65	-
18. 3.76	-	24. 3.76	32.0	11.8	68	-
25. 3.76	-	31. 3.76	35.2	14.7	53	-

The detailed list of those varieties is included in Table 2.

Post sowing operations

In addition to the showers obtained during the seasons, three irrigations were given at an interval of 20 to 25 days. Fertilizer was applied in the form of Ammonium sulphate at the rate of 40 kg N/ha in two equal dozes, at the time of first and second irrigation. The information regarding the temperature, rainfall and humidity during the period of experiment is given in Table 1.

Characters studied

The following 15 characters were selected for the present studies.

1. Days to emergence of flag leaf.
2. Days to maturity.
3. Plant height.
4. Number of tillers.
5. Number of leaves.
6. Leaf angle.
7. Leaf area.
8. Green weight of stem.
9. Green weight of leaves.
10. Total green yield.

11. Stem/leaf ratio.
12. Total dry matter yield.
13. Per cent dry weight.
14. Per cent crude protein; and
15. Per cent ash content.

Observations

Four plants of every variety were randomly selected from each replication for all the morphological as well as biochemical studies at half milk stage, except for days to emergence of flag leaf and days to maturity where the entire population was taken in to consideration and the average was taken.

Detailed procedure followed

1. Days to emergence of flag leaf: The number of days were counted from the date of sowing to the date when the fla leaf emerged completely, in 50 per cent of the plants.

2. Days to maturity: The number of days taken to maturity were counted from the date of sowing to the date when 5 per cent plants become half milk stage (Schmidt,D.R.,19

3. Plant height: The plants were pulled out and a length of 5 cm. of the stem portion from the root initiation point was removed and the height of the highest tiller was recorded in cms. to the nearest one tenth of a cm. (Bohra *et al.*, 1969).

11. Stem/leaf ratio.
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4. Number of tillers: The tilers from each plant were separated and counted.

5. Number of leaves: The leaves were removed excluding leaf sheath from all the tillers and counted.

6. Leaf angle: The leaf angle was measured at the time of maturity while the plants were standing in the field. The procedure given by Seetak et al. (1971) was adopted to measure the leaf angle. The angle between axis and the leaf blade of three leaves below flag leaf of the main tiller was recorded and the average was taken.

7. Leaf area: The length and breadth of three leaves below flag leaf of the main tiller were recorded and the area calculated as per method suggested by Carleton and Foote (1965) and was given as leaf product method by Jain, T.C. and Misra, D.K. (1966).

8. Green weight of the stem: The leaves were removed from all the tillers and the weight including flower head was recorded in grams to the nearest one hundredth of a gram.

9. Green weight of leaves: The weight was taken in grams to the nearest one hundredth of a gram of all leaves, separated from a single plant (Kilcher and Trolsen, 1973).

10. Total green yield: The green weight of stem and leaves were added to get the total green yield of the plant.

11. Stem/leaf ratio: The stem/leaf ratio was calculated on the basis of green weight of stem and leaves.

12. Total dry matter yield? Chopped leaves and stem portions were taken in paper bags which were uniformly perforated with paper punching machine and kept in hot air oven at 80°C till constant weight was attained to the nearest one hundredth of a gram.

13. Per cent dry weight: The per cent dry weight was calculated on the basis of green weight of the whole plant and the weight of dry matter ($\frac{\text{Total dry wt.}}{\text{Total green wt.}}$ x

14. Per cent of crude protein: The whole plant was ground to pass a 40 mm mesh and nitrogen was estimated by Kjeldar method. The procedure suggested by Snell and Snell (1955) was followed for the estimation of protei content.

15. Per cent of ash content: Th ground sample was heated to 600°C in a muffle furna for 4 hours and weighed. The percentage was calculted on the basis of total dry weight (Hunt, L.A.,1966 a Fisher and Fowler, 1975).

Statistical analysis

The mean of 4 plant every variety in each replication was taken as the e of that particular

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11. Stem/leaf ratio: The stem/leaf ratio was calculated on the basis of green weight of stem and leaves.

12. Total dry matter yield? Chopped leaves and stem portions were taken in paper bags which were uniformly perforated with paper punching machine and kept in hot air oven at 80°C till constant weight was attained to the nearest one hundredth of a gram.

13. Per cent dry weight: The per cent dry weight was calculated on the basis of green weight of the whole plant and the weight of dry matter ($\frac{\text{Total dry wt.}}{\text{Total green wt.}} \times 100$)

14. Per cent of crude protein: The whole plant was ground to pass a 40 mm mesh and nitrogen was estimated by Kjeldar method. The procedure suggested by Snell and Snell (1955) was followed for the estimation of protein content.

15. Per cent of ash content: The ground sample was heated to 600°C in a muffle furnace for 4 hours and weighed. The percentage was calculated on the basis of total dry weight (Hunt, L.A.,1966 and Fisher and Fowler, 1975).

Statistical analysis

The mean of 4 plants of every variety in each replication was taken as the value of that particular replication for all the calculations. The data thus obtained were processed by analysis of variance for various analysis like genotypic and phenotypic variances, heritability, genetic advance, genetic gain, genetic coefficient of variation, genotypic and phenotypic covariances, correlations and path coefficients.

Genetic variability

The analysis was done by the method suggested by Panse and Sukhatme (1961) for randomised block design. The variations among individuals caused by genetic reasons were measured by using the following formula:-

$$Vg = \frac{MSV - VE}{N}$$

where Vg = Genetic variance.

MSV = Mean sum of squares of variation.

VE = Error variance.

N = Number of replications.

Phenotypic variability:

The actual visual variation among individuals is due to genetic as well as environmental causes. This can be measured using the formula:

$$Vph = Vg + VE$$

where Vph = Phenotypic variance.

Vg = Genotypic variance.

VE = Environmental variance.

The formula used in the present study was

$$Vph = Vg + \frac{VE}{N}$$

where VE = Error variance

N = Number of replications.

Heritability

The heritability is the potentiality of an individual to inherit a particular character to its off spring. In broad sense, it is equivalent to the total genetic variations divided by the total phenotypic variation and is denoted in percentage. The heritability in broad sense was calculated by the formula suggested by Burton and Devane (1953) and Johnson et al. (1955) where it is given :

$$H = \frac{Vg}{Vph} \times 100$$

where H = Heritability.

Vg = Genetic variance.

Vph = Phenotypic variance.

Expected genetic advance

At a certain level of selection pressure the shift of a population towards the superior side of genetic action is meant by genetic advance. The genetic advance of the population under these studies was calculated by the formula given by Lush (1949) and Johnson et al. (1955a) at 5 per cent selection pressure using the constant K as 2.06 given by Allard (1960).

$$GA = \frac{Vg}{Vph} \times \sqrt{Vph} \times K$$

$$= \frac{Vg}{\sqrt{Vph}} \times K$$

where GA = Genetic advance.

Vg = Genetic variance.

Vph = Phenotypic variance.

K = Selection differential (Constant).

Genetic gain

Genetic gain is the percentage of expected genetic advance based on the mean of the particular character under study. The method for the assessment of genetic gain suggested by Johnson et al. (1955) was used which is as follows:

$$\text{Genetic gain (G.G.)} = \frac{GA}{\bar{X}} \times 100$$

where G.A. = Genetic advance.

$\bar{X}$ = Mean of character.

Genetic coefficient of variation

To work out the magnitude of genetic variation in a character, genetic coefficient of variation was calculated by the formula suggested by Burton (1955) which is as follows:

$$\text{Genetic coefficient of variation (G.C.V.)} = \frac{\sqrt{Vg}}{\bar{X}} \times 100$$

where Vg = Genetic variance.

$\overline{X}$ = Mean character under study.

<u>Genotypic and phenotypic covariances and correlation coefficients</u>

The genotypic and phenotypic covariances were worked out in the same way as the variances were calculated. Mean product of the expectation of covariance analysis is similar to the mean square expectation for analysis of variance. The phenotypic and genotypic correlations between dry matter yield and all the other characters were worked out by substituting the genotypic and phenotypic covariances and variances in the formula suggested by Fisher (1954) and Aljbouri *et al.*(1958).

Genotypic correlation coefficient between two characters (1) and (2) $= r_{1 \cdot 2} = \dfrac{g\ Cov\ 1 \cdot 2}{\sqrt{(\sigma^2_g \cdot 1)\ (\sigma^2_g \cdot 2)}}$

Phenotypic correlation coefficient between two characters (1) and (2) $= r_{1 \cdot 2} = \dfrac{ph\ Cov\ 1.2}{\sqrt{(\sigma^2_{ph} \cdot 1)\ (\sigma^2_{ph} \cdot 2)}}$

where $g\ Cov\ 1.2$ = Genotypic covariances of characters in pairs.

$ph\ Cov\ 1.2$ = Phenotypic covariances of characters in pairs.

$\sigma^2_g \cdot 1$ = Genotypic variance of the first character.

$\sigma^2_g . 2$ = Genotypic variance of the second character.

$\sigma^2 ph.1$ = Phenotypic variance of the first character.

$\sigma^2 ph.2$ = Phenotypic variance of the second character.

<u>Path coefficient analysis</u>

The principles and technique suggested by Wright (1921) and Li (1955) for the cause and effect system were adopted for the analysis, using the formula given by Dewey and Lu (1959). Since almost all the traits were significantl correlated at 1 per cent level with dry matter yield, heritability, expected genetic advance, genetic gain and genetic coefficient of variation were also taken into account to select the characters for path coefficient analysis, and accordingly the following characters were selected.

1. Grainweight of the stem.
2. Green weight of the leaves.
3. Plant height.
4. Number of tillers.
5. Leaf area.
6. Number of leaves.
7. Total dry matter yield.

The correlations between first six characters listed above were also worked out in all possible combination.

The design adopted by Durate and Alams (1972) was choosen for further analysis of path coefficient. The diagrammatic representation of path and its relationship is given in Plate I.

Thd diagram includes first order and second order components. Characters 1 and 2, (green weight of stem and green weight of leaves) were taken as first order components because these two characters were the major causes to influence the dry matter yield. The other characters like, plant height, number of tiller, leaf area and number of leaves were taken as second order componente, since their main effects were through the increase of stem weight and the weight of leaves to give an ultimate increase in dry matter yield.

The double arrowed lines in the diagram indicate the mutual association between characters. The single arrowed lines indicate direct effect measured as path coefficients. The path coefficients were worked out by solving the following three sets of linear equations using matrix method.

<u>Linear equations</u>

I. <u>First order components</u>

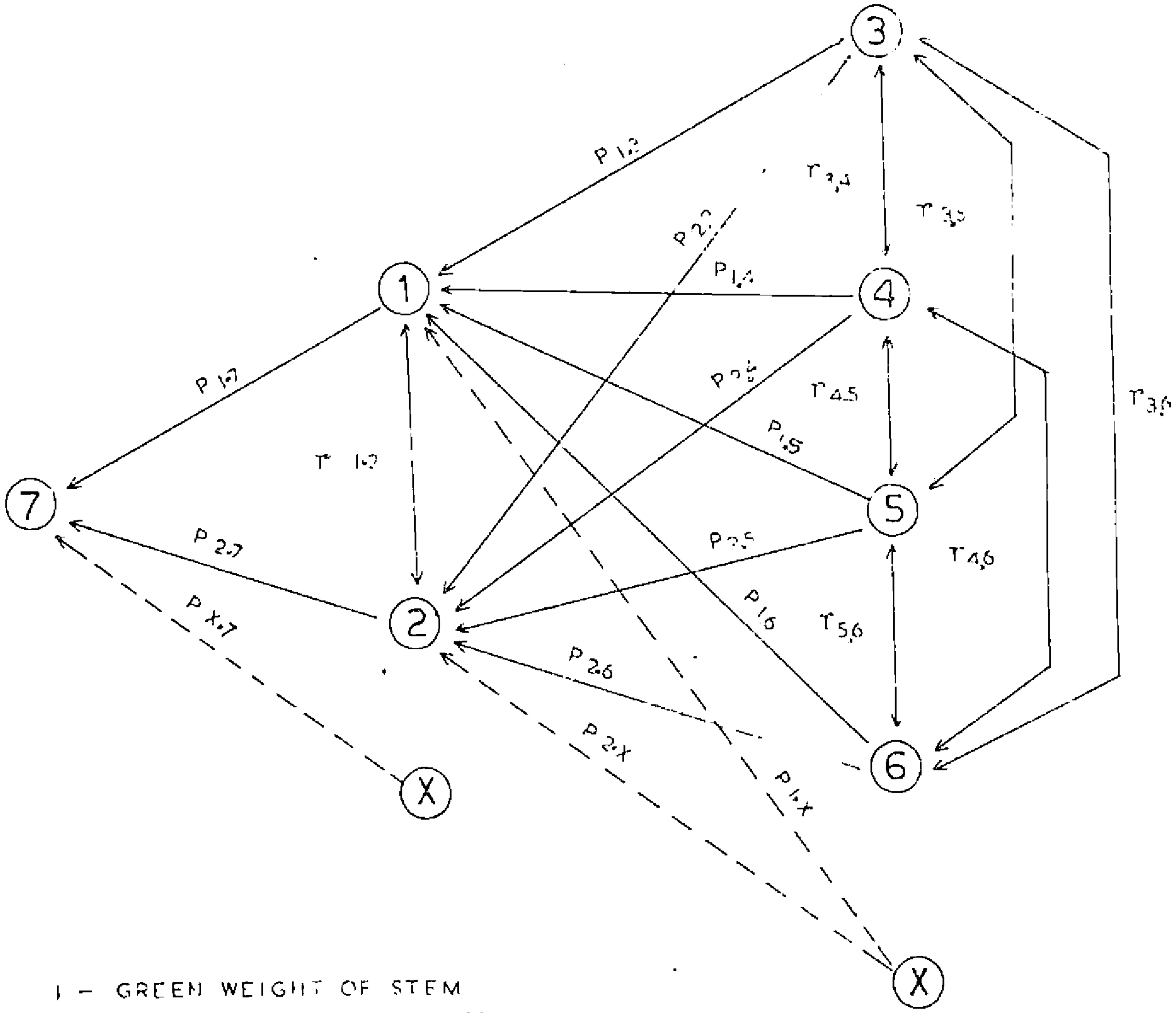
$$r_{(1,7)} = P_{1.7} + r_{(1,2)} P_{2.7}$$

$$r_{(2,7)} = P_{2.7} + r_{(1,2)} P_{1.7}$$

$$1 = P^2_{x.7} + P^2_{1.7} + P^2_{2.7} + 2r_{(1,2)} P_{1.7}\ P_{2.7}\ .$$

PLATE No I

DIAGRAMMATIC REPRESENTATION OF PATH AND ITS RELATIONSHIPS



1 – GREEN WEIGHT OF STEM
2 – GREEN WEIGHT OF LEAVES
3 – PLANT HEIGHT
4 – NUMBER OF TILLERS
5 – LEAF AREA
6 – NUMBER OF LEAVES
7 – TOTAL DRY MATTER YIELD
X – RESIDUAL FACTOR

II. Second order components

(a) Green weight of stem and its components

$$r_{(1,3)} = P_{1.3} + r_{(3,4)}P_{1.4} + r_{(3,5)}P_{1.5} + r_{(3,6)}P_{1.6}$$

$$r_{(1,4)} = P_{1.4} + r_{(3,4)}P_{1.3} + r_{(4,5)}P_{1.5} + r_{(4,6)}P_{1.6}$$

$$r_{(1,5)} = P_{1.5} + r_{(4,5)}P_{1.4} + r_{(3,5)}P_{1.3} + r_{(5,6)}P_{1.6}$$

$$r_{(1,6)} = P_{1.6} + r_{(5,6)}P_{1.5} + r_{(4,6)}P_{1.4} + r_{(3,6)}P_{1.3}$$

$$1 = P^2_{x1} + P^2_{1.3} + P^2_{1.4} + P^2_{1.5} + P^2_{1.6} + 2P_{1.3}r_{(3,4)}P_{1.4} +$$

$$2P_{1.3}r_{(3,5)}P_{1.5} + 2P_{1.3}r_{(3,6)}P_{1.6} + 2P_{1.4}r_{(4,5)}P_{1.5} +$$

$$2P_{1.4}r_{(4,6)}P_{1.6} + 2P_{1.5}r_{(5,6)}P_{1.6}.$$

(b) Green weight of leaves and its components

$$r_{(2,3)} = P_{2.3} + r_{(3,4)}P_{2.4} + r_{(3,5)}P_{2.5} + r_{(3,6)}P_{2.6}$$

$$r_{(2,4)} = P_{2.4} + r_{(3,4)}P_{2.3} + r_{(4,5)}P_{2.5} + r_{(4,6)}P_{2.6}$$

$$r_{(2,5)} = P_{2.5} + r_{(4,5)}P_{2.4} + r_{(3,5)}P_{2.3} + r_{(5,6)}P_{2.6}$$

$$r_{(2,6)} = P_{2.6} + r_{(5,6)}P_{2.5} + r_{(4,6)}P_{2.4} + r_{(3,6)}P_{2.3}$$

$$1 = P^2_{x.2} + P^2_{2.3} + P^2_{2.4} + P^2_{2.5} + P^2_{2.6} + 2P_{2.3}r_{(3,4)}P_{2.4} +$$

$$2P_{2.3}r_{(3,5)}P_{2.5} + 2P_{2.3}r_{(3,6)}P_{2.6} + 2P_{2.4}r_{(4,5)}P_{25} +$$

$$2P_{2.4}r_{(4,6)}P_{2.6} + 2P_{2.5}r_{(5,6)}P_{2.6}.$$

......

EXPERIMENTAL RESULTS

Mean values, range, S.E.(d) and critical difference for the fifteen characters were calculated. The results are arranged in table 2.

All the characters analysed for variance exhibited highly significant differences (at one per cent level). Total green yield per pland had the highest phenotypic and genotypic variances (G = 2036.4552, P = 2244.2215), followed by green weight of stem (G = 999.3724, P = 1102.2112), number of leaves (G = 223.6452, P = 232.8872), leaf area (G = 219.6572, P = 231.9114), green weight of leaves (G = 209.0634, P = 273.4815), plant height (G = 117.6519, P = 127.6873) and days to flag leaf emergence (G = 100.7543, P = 101.0622). The minimum values observed were for stem/leaf ratio (G = 0.2409, P = 0.2442). The variance in crude protein percentage (G = 1.5934, P = 2.2248) and percentage of ash content (G = 2.3259, P = 2.6791) were also low compared to the other characters (Table 3 and Appenix I-XV).

Heritability

Days to flag leaf emergence and days to maturity had the highest heritability values (99.696 and 99.681

TABLE 2

Mean, Range, Standard error, Critical difference and over all mean of the characters studied

S. No.	Varieties	Days to flag leaf emergence	Days to Maturity	Plant Height	Number of Tillers	Number of leaves	Leaf angle	Leaf area	Green weight of stem
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	E.C.55197	90.500	113.000	135.000	14.150	61.150	29.175	59.400	136.225
2.	Flamingold	104.250	119.500	128.200	11.200	55.025	31.900	53.950	97.075
3.	E.C.99162	98.500	117.500	133.850	9.200	38.475	29.700	69.200	145.700
4.	Kent	98.500	118.500	126.200	8.200	39.225	30.300	64.325	94.250
5.	Reed.19	93.750	112.500	131.900	10.325	47.175	29.500	66.525	105.800
6.	E.C.99166	103.500	121.000	132.350	6.125	34.400	25.675	77.975	95.575
7.	E.C.54833	87.300	101.100	129.200	14.125	68.600	28.675	54.200	130.950
8.	E.C.43536	108.300	125.750	132.575	13.250	58.275	35.125	87.800	126.675
9.	E.C.99164	93.750	110.750	130.650	12.325	66.600	24.650	39.225	107.400
10.	E.C.99167	100.000	117.250	111.850	11.450	62.875	29.650	48.225	104.850
11.	I.C. 1819	83.750	100.500	128.125	11.750	62.625	24.400	56.675	148.250
12.	E.C.43665	91.500	110.750	131.550	14.700	17.650	27.975	46.875	138.050
13.	E.C.99161	99.000	118.000	139.325	11.500	45.725	29.700	56.025	113.825
14.	E.C.99165	99.900	119.750	126.150	14.870	83.825	24.550	50.225	147.825
15.	E.C.99163	99.000	119.000	148.150	13.950	66.200	28.250	69.675	163.550
16.	E.C.96573	107.750	124.000	123.150	7.250	31.675	23.725	61.350	67.900
17.	E.C.43535	79.750	99.000	106.650	12.750	64.700	29.625	28.850	107.125
18.	I.C. 1829	85.000	105.000	115.850	11.200	59.500	26.125	45.150	109.425
19.	E.C.54937	94.000	111.250	108.475	15.575	61.150	30.925	30.850	130.175
20.	E.C.43666	108.300	124.500	119.950	7.075	30.200	22.375	64.400	71.925
21.	I.C. 1820	87.000	106.750	133.025	14.450	68.400	38.275	36.375	114.225

(Continued)

(Table 2 contd.)

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
22.	Algerion	91.000	110.250	156.200	13.325	63.400	28.050	54.300	154.975
23.	E.C.96552	81.500	98.500	129.825	17.325	85.200	31.625	49.625	176.475
24.	Acassa	95.000	125.250	129.075	14.825	68.650	32.250	67.925	189.225
25.	E.C.86444	95.000	114.500	122.525	12.825	47.225	26.725	60.825	114.075
26.	E.C.96529	95.000	114.000	116.350	12.625	64.100	26.025	51.050	100.775
27.	Rapida	68.000	85.000	109.225	5.200	24.775	28.250	28.025	45.000
28.	N.P. 101	83.000	102.500	127.025	9.500	43.025	29.425	29.900	78.400
29.	X.27	83.000	101.750	120.925	7.625	37.725	27.550	58.025	82.250
30.	E.C.86445	73.000	92.750	114.600	11.500	49.025	32.150	31.150	84.175
31.	E.C.54834	77.000	95.750	107.957	12.250	67.275	31.550	29.525	107.325
32.	E.C.96531	93.750	111.000	110.325	13.575	62.900	26.925	60.575	120.750
	Overall Mean($\bar{x}$)	92.085	110.515	125.522	11.671	56.054	28.775	52.756	115.803
	Range	68.000 - 108.300	85.500 - 125.750	106.650 - 156.200	5.200 - 17.325	24.775 - 85.200	22.375 - 35.125	28.025 - 87.800	45.000 189.225
	S.E.(d)±	0.301	0.311	3.190	0.652	3.042	0.733	4.309	10.141
	C.D. at 5%	1.544	1.572	8.957	1.803	8.536	2.049	12.100	28.473

TABLE 2 (Contd.)

S. No.	Varieties	Green weight of leaves	Total green yield	Stem/leaf ratio	Total dry matter yield	Per cent dry weight	Per cent crude protein	Per cent ash content
1.	2.	11.	12.	13.	14.	15.	16.	17.
1.	E.C.55197	65.550	201.750	2.08975	47.225	24.375	10.895	12.075
2.	Flamingold	36.587	133.850	2.68050	37. 975	28.625	12.713	11.475
3.	E.C.99162	49.460	165.200	2.34390	44.450	29.250	12.970	12.975
4.	Kent	43.325	137.600	2.21075	32.925	27.600	11.932	9.975
5.	Reed. 19	43.040	148.875	2.23075	39.725	26.650	15.045	11.500
6.	E.C.99166	40.090	135.675	2.40950	30.850	25.075	12.192	4.600
7.	E.C.54933	52.637	186.150	2.49450	39.675	24.600	11.932	12.250
8.	E.C.43536	61.142	173.950	2.26500	47.850	29.800	16.600	12.275
9.	E.C.99164	40.640	148.050	2.64250	37.775	28.475	15.822	10.950
10.	E.C.99167	52.135	132.050	1.99125	36.925	28.450	12.710	11.725
11.	I.C. 1819	55.742	204.025	2.75475	45.650	24.250	10.637	12.900
12.	E.C. 43665	46.582	184.650	3.03775	49.600	28.625	10.895	10.775
13.	E.C.99161	45.240	159.100	2.55800	44.650	29.800	11.933	12.300
14.	E.C.99165	75.205	218.100	2.10000	49.400	24.450	15.045	12.650
15.	E.C.99165	[illegible]	268.050	2.32275	63.475	24.950	11.415	13.800
16.	E.C.9653	31.150	92.450	2.01525	27.100	32.250	11.672	11.975
17.	E.C.43535	45.450	142.625	3.01850	34.000	28.850	11.932	10.325
18.	I.C. 1829	45.942	155.350	2.38425	39.000	27.875	12.452	11.900
19.	E.C.54937	35.422	165.625	3.68475	53.275	33.775	10.895	11.725
20.	E.C.43666	32.085	140.050	2.30575	30.800	32.225	10.637	10.150
21.	I.C. 1829	46.997	136.255	2.40225	41.025	29.150	11.672	12.025

(Continued)

(Table 2 contd.)

1.	2.	11.	12.	13.	14.	15.	16.	17.
22.	Algerion	56.847	211.375	2.73200	54.750	27.425	10.637	11.125
23.	E.C.96552	65.305	216.825	2.72050	52.375	25.500	12.450	8.400
24.	Acacea	90.627	279.875	2.20600	58.550	25.300	11.670	11.125
25.	E.C.86444	44.657	158.775	2.55350	39.825	27.175	10.897	11.800
26.	E.C.96529	49.850	149.875	2.04450	38.950	28.500	11.157	11.850
27.	Rapida	11.767	56.750	3.88725	15.625	32.300	12.972	9.850
28.	N.P.101	21.337	89 .775	3.68000	35.675	36.125	11.932	11.250
29.	X.27	31.252	113.825	2.75475	31.700	31.050	11.935	9.525
30.	E.C.86455	25.272	112.000	3.33425	27.325	25.825	11.672	11.150
31.	E.C.54834	39.062	146.700	2.75225	33.125	25.025	11.192	11.300
32.	E.C.96531	58.397	178.525	2.08975	41.550	25.850	11.157	12.175
	Overall mean($\bar{x}$)	46.997	159.117	2.59125	40.736	27.764	12.208	10.950
	Range	11.767 - 90.627	56.750 - 279.857	1.99125 - 3.88725	15.625 - 63.425	24.300 - 36.125	10.637 - 16.660	8.400 - 13.800
	S.E.(d)±	4.943	14.415	0.07300	2.932	1.024	0.828	1.157
	C.D. at 5%	13.879	40.477	0.20490	8.233	2.877	2.325	2.296

TABLE 3

Genotypic, phenotypic and error variances of characters studied

S. No.	Characters	Genotypic variance	Phenotypic variance	Error variance
1.	Days to flag leaf emergence	100.7543	101.0622	1.2043
2.	Days to maturity	97.6854	98.0000	1.2473
3.	Plant height	117.6519	127.7863	40.5763
4.	Number of tillers	8.6931	9.1159	1.7068
5.	Number of leaves	223.6452	232.8872	37.0224
6.	Leaf angle	10.0916	10.6251	2.1398
7.	Leaf area	219.6572	231.9114	74.2239
8.	Green weight of stem	999.3724	1102.2112	411.3739
9.	Green weight of leaves	209.0634	273.4815	97.6739
10.	Total green yield	2036.4552	2244.2215	831.0397
11.	Stem/leaf ratio	0.2409	0.2442	0.0128
12.	Total dry matter yield	92.6571	101.2532	34.4012
13.	Per cent dry weight	8.3576	9.4116	4.2224
14.	Per cent crude protein	1.5384	2.2248	2.7457
15.	Per cent ash content	2.3259	2.6791	2.6800

per cent respectively). Only the characters like per cent crude protein (69.147), per cent ash content (86.567) and per cent dry weight (88.799) manifested heritability values less than 90 per cent.

Expected genetic advance

The total green yield per plant had the highest genetic advance (88.661) followed by green weight of stem (62.013) and green weight of leaves (36.769). The number of leaves per plant (30.176) and plant height (25.438) also had high genetic advance. The least value of expected genetic advance obtained was (1.004) for stem/leaf ratio.

Genetic gain

The highest genetic gain was observed for green weight of leaves (78.237) followed by leaf area (56.235), total green weight (54.526), number of leaves (53.833), green weight of stem (53.550) and number of tillers (50.792). Almost all the characters except per cent dry weight (5.612) and days to flag leaf emergence (2.241) had high values of genetic gain (range 17.357 to 78.237).

Genetic coefficient of variation

The characters which had moderately high values of heritability, expected genetic advance and genetic gain exhibited comparatively high genetic coefficient of variation (range 8.636 to 33.688). The highest value of G.C.V. was obtained in green weight of leaves (33.688). The other characters like, leaf area (28.092), total green yield (27.770), green weight of stem (27.283), number of leaves (26.672) and number of tillers (25.364) also had much higher values. Lower G.C.V. values were observed for dry matter yield (8.174) and plant height (8.636).

The expected manifestation of heritability, genetic advance, genetic gain and genetic coefficient of variation in all the characters under study are given in table 4.

Association of characters

To find out the various dependent components of dry matter yield and their extend of association, the genotypic and phenotypic correlation coefficients were analysed with the help of genotypic and phenotypic variances and covariances analysis. The results are given in table 5 and appendix XVI-XVII.

Genotypic and phenotypic correlations between characters

The values of genotypic correlation of all characters were almost similar to that of phenotypic values, although on slightly to the higher side, indicating the least environmental influence. Highest positive association with dry matter yield was observed of green weight of stem

TABLE 4

Heritability, expected genetic advance, genetic gain and genetic coefficient of variation of characters studied

S. No.	Characters	Herita-bility	Expected genetic advance	Genetic gain	G.C.V.
1.	Days to flag leaf emergence	99.696	20.640	2.241	8.940
2.	Days to maturity	99.681	20.326	18.392	10.903
3.	Plant height	92.065	25.438	20.265	8.636
4.	Number of tillers	95.285	5.928	50.792	25.364
5.	Number of leaves	96.028	30.176	53.833	26.672
6.	Leaf angle	95.009	6.379	22.168	11.053
7.	Leaf area	94.713	29.715	56.325	28.092
8.	Green weight of stem	90.670	62.013	53.550	27.288
9.	Green weight of leaves	91.158	36.769	78.237	53.688
10.	Total green yield	90.742	88,561	54.526	27.770
11.	Stem/leaf ratio	98.686	1.004	38.749	18.950
12.	Total dry matter weight	91.506	18.960	46.543	8.714
13.	Per cent dry weight	88.799	5.613	5.612	10.410
14.	Per cent crude protein	69.147	2.119	17.357	10.163
15.	Per cent ash content	86.567	2.925	26.712	13.831

TABLE 5

Genotypic and phenotypic correlation coefficients between total dry matter yield and all other characters

S. No.	Characters	Total dry matter yield	
		Genotypic correlation coefficient	Phenotypic correlation coefficient
1.	Days to flag leaf emergence	+ 0.28382**	+ 0.27199**
2.	Days to maturity	+ 0.30792**	+ 0.30214**
3.	Plant height	+ 0.59377**	+ 0.56193**
4.	Number of tillers	+ 0.79507**	+ 0.75309**
5.	Number of leaves	+ 0.70304**	+ 0.67289**
6.	Leaf angle	+ 0.19921*	+ 0.17502
7.	Leaf area	+ 0.31131**	+ 0.30709**
8.	Green weight of stem	+ 0.95113**	+ 0.93331**
9.	Green weight of leaves	+ 0.82464**	+ 0.83709**
10.	Total green yield	+ 0.93776**	+ 0.91237**
11.	Stem/leaf ratio	- 0.26908**	- 0.23577**
12.	Per cent dry weight	- 0.25619**	- 0.23076**
13.	Per cent crude protein	- 0.10192	- 0.06444
14.	Per cent ash content	+ 0.28501**	+ 0.21605**

* Significant at 5 per cent level

** Significant at 1 per cent level

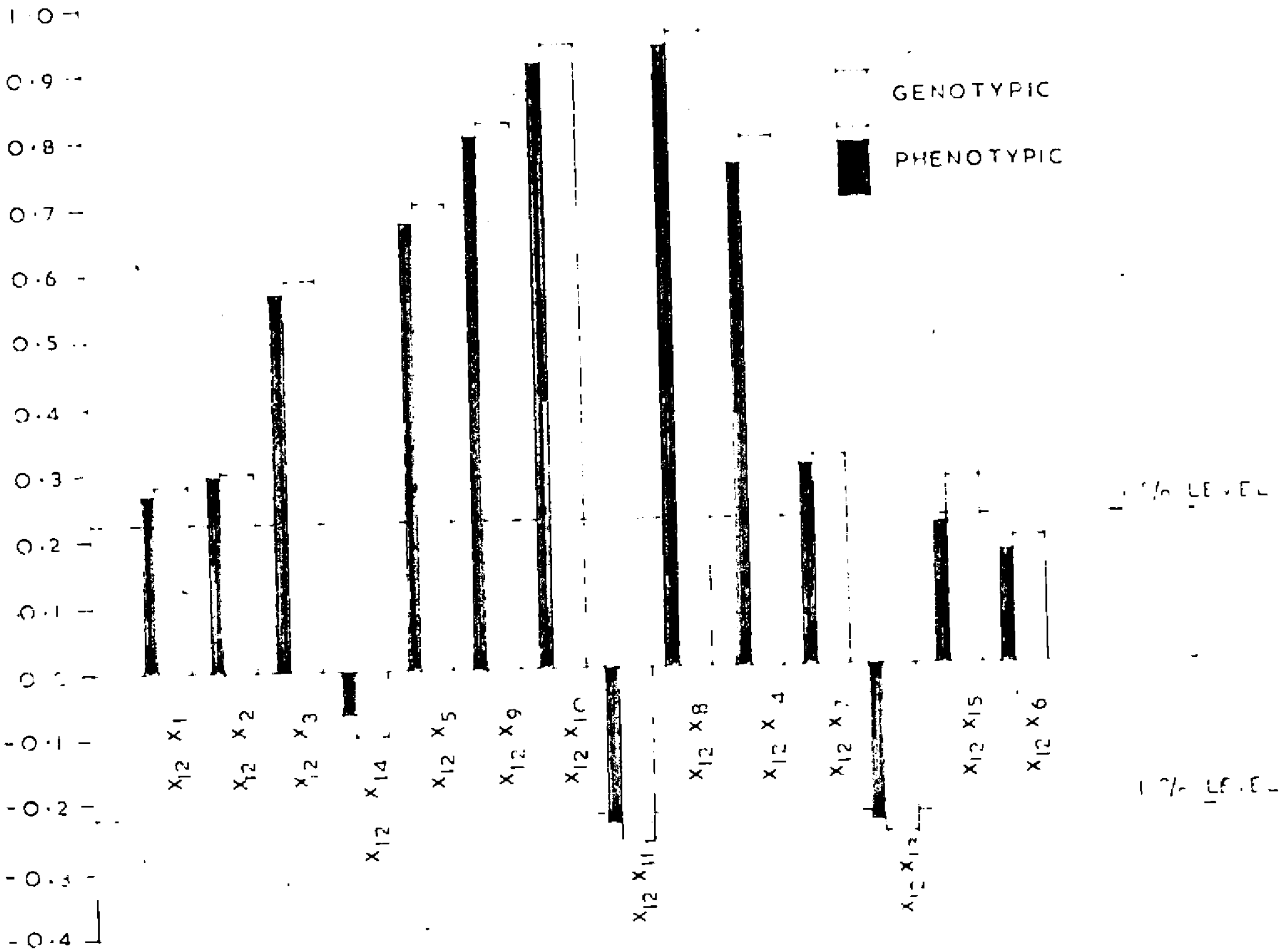
with dry matter yield (G = +0.95113, P =+0.93331) followed by total green weight (G = +0.93776, P = +0.91237), green weight of leaves (G = +0.82464, P = +0.80709), number of tillers (G = +0.79507, P = +0.75309), number of leaves (G = +0.70304, P = +0.67289), plant height (G = +0.59877, P = +0.56193), leaf area (G = +0.31131, P = +0.30708), days to maturity (G = +0.30792, P = +0.30214), per cent ash content (G = +0.28501, P = +0.21605) and days to flag leaf emergence (G = +0.28382, P = +0.27199). Positive but non significant correlation at 1 per cent level was observed with leaf angle (G = +0.19921, P = +0.17502). Stem/leaf ratio (G = -0.26908, P = -0.23577) and per cent dry weight (G = -0.25619, P = -0.23076) had high significant negative correlation with dry matter yield. The relationship of per cent crude protein with dry matter yield was negative and non significant (G = -0.10192, P = -0.06444). The graphic representation of the values are given in Plate II.

Reviewing the above correlation values of various characters with total dry matter yield and their heritability, genetic coefficient of variation and genetic gain values the following characters were selected for path analysis.

1. Green weight of stem.
2. Green weight of leaves.
3. Plant height.
4. Number of tillers.
5. Leaf area.
6. Number of leaves.

PLATE No 11

CORRELATION COEFFICIENT VALUES BETWEEN DRY MATTER YIELD AND ALL OTHER CHARACTERS



WHERE A

X_1 - DAYS TO FLAG LEAF EMERGENCE
X_2 - DAYS TO MATURITY
X_3 - PLANT HEIGHT
X_4 - NUMBER OF TILLERS
X_5 - NUMBER OF LEAVES
X_6 LEAF ANGLE
X_7 - LEAF AREA
X_8 - GREEN WEIGHT OF STEM
X_9 - GREEN WEIGHT OF LEAVES
X_{10} - TOTAL GREEN WEIGHT
X_{11} - STEM / LEAF RATIO
X_{12} - TOTAL DRYMATTER YIELD
X_{13} - PER CENT DRY WEIGHT
X_{14} - PER CENT CRUDE PROTEIN
X_{15} - PER CENT ASH CONTENT

As, out of the above characters the first two, i.e. green weight of stem and green weight of leaves were the only components contributing directly towards the total dry matter yield and hence were taken as first order components and the rest of the characters as they influence the dry matter yield only through stem and/or leaf green weight, were grouped under second order components in path analysis.

In order to work out the path coefficient analysis the mutual relationships between the characters of the first order components and that of second order components were also worked out. As in path analysis we are concerned only with genotypic correlations, hence now onward reference has been made only to genotypic correlation values.

Green weight of stem had a higher genotypic correlation coefficient (+ 0.95113) with total dry matter yield than green weight of leaves (+0.82464). Association between green weight of stem and green weight of leaves were also very high (+ 0.92032). (Table 6 and Plate III).

Among the characters of second order components, the number of tillers (+ 0.83544)had the highest correlatic with green weight of stem followed by number of leaves (+ 0.79679), plant height (+ 0.52455) and leaf area(+0.267 The association of above four characters with green weight of leaves was also found to be in the same pattern. The num of tillers had the highest value (+0.70409) followed by

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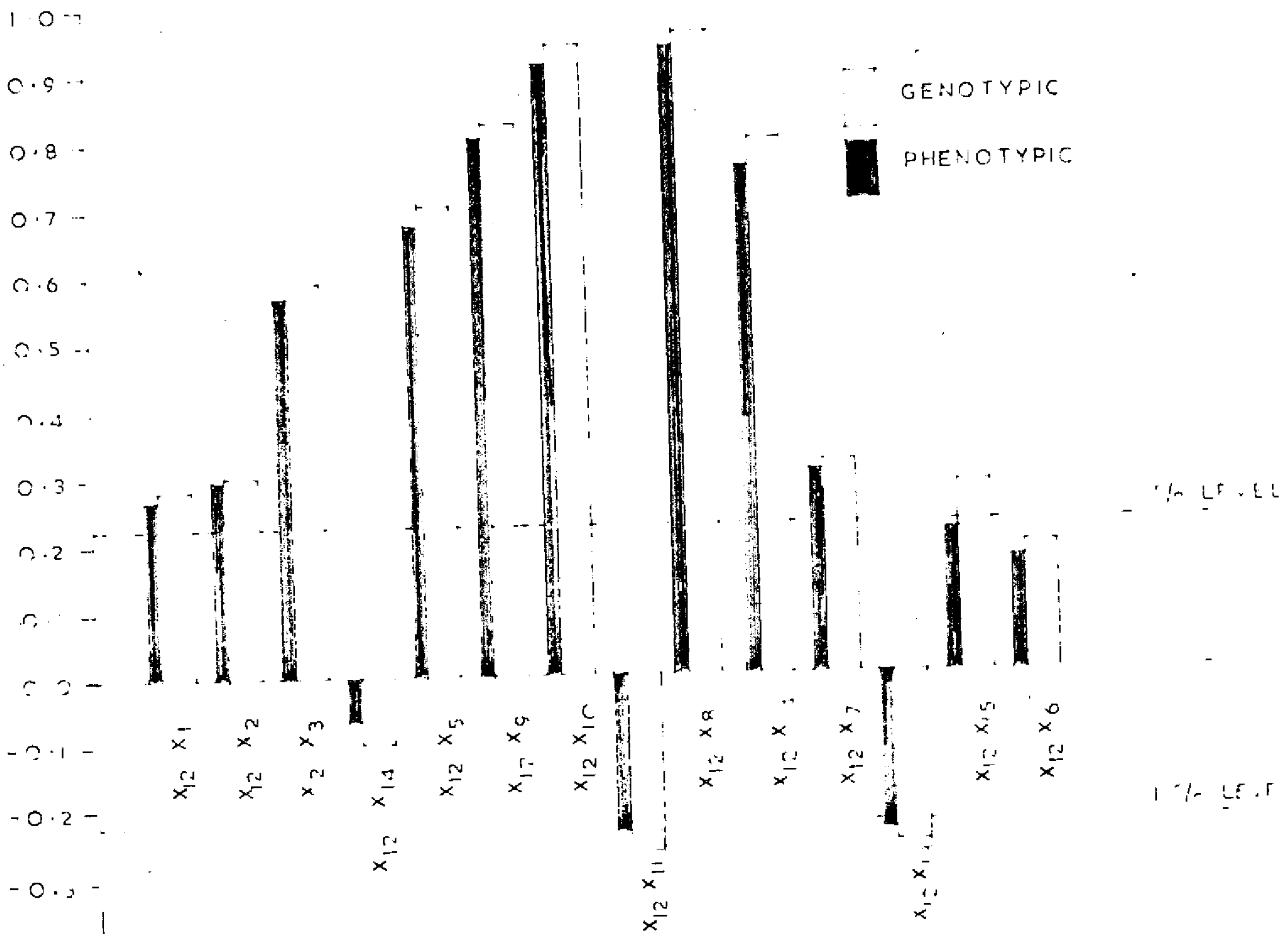
PLATE No 11

CORRELATION COEFFICIENT VALUES BETWEEN DRY MATTER YIELD AND ALL OTHER CHARACTERS



WHERE A

X_1 - DAYS TO FLAG LEAF EMERGENCE
X_2 - DAYS TO MATURITY
X_3 - PLANT HEIGHT
X_4 - NUMBER OF TILLERS
X_5 - NUMBER OF LEAVES
X_6 - LEAF ANGLE
X_7 - LEAF AREA
X_8 - GREEN WEIGHT OF STEM
X_9 - GREEN WEIGHT OF LEAVES
X_{10} - TOTAL GREEN WEIGHT
X_{11} - STEM / LEAF RATIO
X_{12} - TOTAL DRYMATTER YIELD
X_{13} - PER CENT DRY WEIGHT
X_{14} - PER CENT CRUDE PROTEIN
X_{15} - PER CENT ASH CONTENT

TABLE 6

The possible genotypic and phenotypic correlation coefficients between total dry matter yield and the characters selected for path coefficient analysis
(first order components)

		Total dry matter yield	Green weight of stem	Green weight of leaves
Total dry matter yield	(G)	x	+ 0.95113**	+ 0.82464**
	(P)		+ 0.93331**	+ 0.83709**
Green weight of stem	(G)	x	x	+ 0.92032**
	(P)			+ 0.90462**
Green weight of leaves	(G)	x	x	x
	(P)			

** Significant at 1 per cent level

number of leaves (+ 0.66597), plant height (+ 0.51515) and leaf area (+ 0.51225).

The highest relationship between number of tillers and number of leaves (+ 0.94920) was observed, followed by between plant height and leaf area (+0.54342), plant height and number of tillers (+ 0.17485) and between plant height and number of leaves (+ 0.10644). Negative association was observed between number of tillers and leaf area (-0.15964) and between number of leaves and leaf area (- 0.20901). (Table 7 and Plate IV).

<u>Path coefficient analysis</u>

<u>First order components</u> (Table 8 and Plate V).

1. <u>Dry matter yield v/s green weight of stem</u>

Path analysis revealed a very high and positive direct effect of green weight of stem (+ 1.25606). However, its indirect effect on total dry matter yield via green weight of leaves was negative (- 0.30493). Thus the total correlation coefficient was only a part reflection of its direct effect as partly it was nullified by the indirect effect through green weight of leaves.

2. <u>Dry matter yield v/s green weight of leaves</u>

The simple correlation coefficient of green weight of leaves with total dry matter yield was (+ 0.82464).

TABLE 7

The possible genotypic and phenotypic correlation coefficients between second order components selected for path coefficient analysis

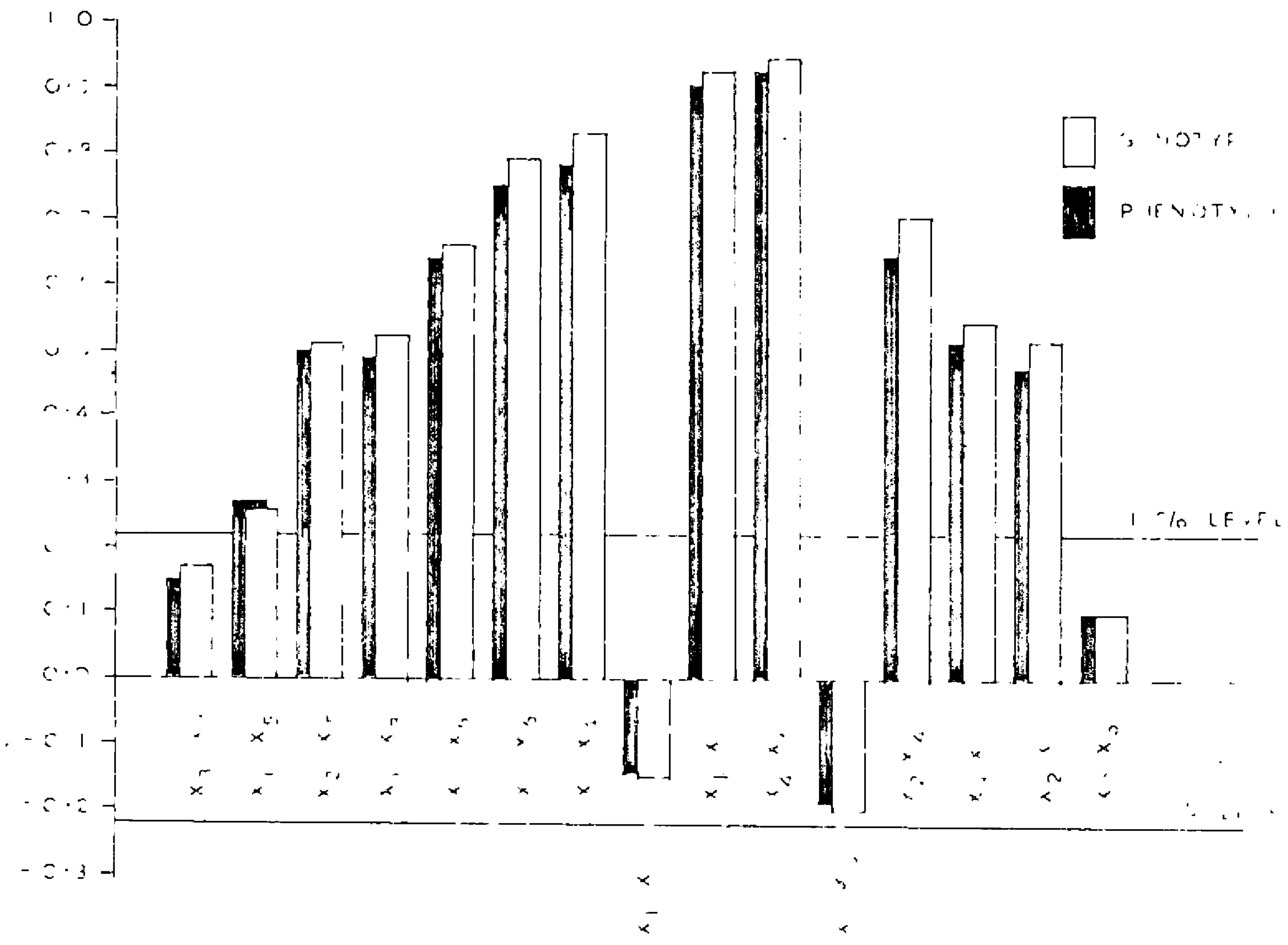
		Green weight of stem	Green weight of leaves	Plant height	Number of tillers	Leaf area	Number of leaves
Green weight of stem	(G)	x	+ 0.92032**	+ 0.52455**	+ 0.83544**	+ 0.26723**	+ 0.79679**
	(P)		+ 0.90462**	+ 0.49920**	+ 0.78452**	+ 0.27474**	+ 0.75915**
Green weight of leaves	(G)	x	x	+ 0.51515**	+ 0.70409**	+ 0.51224**	+ 0.66597**
	(P)			+ 0.47032**	+ 0.64841**	+ 0.50257**	+ 0.64866**
Plant height	(G)	x	x	x	+ 0.17485	+ 0.54342**	+ 0.10644
	(P)				+ 0.15589	+ 0.51232**	+ 0.10299
Number of tillers	(G)	x	x	x	x	- 0.15964	+ 0.94926**
	(P)					- 0.15149	+ 0.92480**
Leaf area	(G)	x	x	x	x	x	- 0.20901*
	(P)						- 0.19276*
Number of leaves	(G)	x	x	x	x	x	x
	(P)						

* Significant at 5 per cent level.

** Significant at 1 per cent level.

PLATE NO IV

GENOTYPIC AND PHENOTYPIC CORRELATION COEFFICIENTS BETWEEN SECOND ORDER COMPONENTS



WHERE AS

X_1 -- GREEN WT OF STEM

X_2 GREEN WT OF LEAVES

X_3 PLANT HEIGHT

X_4 NO OF TILLER

X_5 LEAF AREA

X_6 NO OF LEAVES

TABLE 8

The direct and indirect relationship between variables of the first order components of total dry matter yield

Variables		Path coefficient
1. Total dry matter yield v/s green wt. of stem	r =	+ 0.95113
Direct effect	$P_{1.7}$ =	+ 1.25606
Indirect effect via green wt. of leaves	$P_{2.7}r_{1.2}$ =	- 0.30493
Total	=	+ 0.95113
2. Total dry matter yield v/s green wt. of leaves	r =	+ 0.82464
Direct effect	$P_{2.7}$ =	- 0.33133
Indirect effect via green wt. of stem	$P_{1.7}r_{1.2}$ =	+ 1.15597
Total	=	+ 0.82464
3. Residual factors	$P_{x.7}$ =	+ 0.28026

TABLE 8

The direct and indirect relationship between variables of the first order components of total dry matter yield

Variables		Path coefficient
1. Total dry matter yield v/s green wt. of stem	r =	+ 0.95113
Direct effect	$P_{1.7}$ =	+ 1.25606
Indirect effect via green wt. of leaves	$P_{2.7}r_{1.2}$ =	- 0.30495
Total	=	+ 0.95113
2. Total dry matter yield v/s green wt. of leaves	r =	+ 0.82464
Direct effect	$P_{2.7}$ =	- 0.33135
Indirect effect via green wt. of stem	$P_{1.7}r_{1.2}$ =	+ 1.15597
Total	=	+ 0.82464
3. Residual factors	$P_{x.7}$ =	+ 0.28026

However, its direct effect was negative (- 0.33133) and the high positive correlation value was solely due to its indirect effect through green weight of stem (+ 1.15597).

Second order components (Table 9 and Plate V).

(a) Green weight of stem and its components

1. Green weight of stem v/s plant height

The correlation coefficient of + 0.52455 between plant height and green weight of stem was mainly due to the direct effect of plant height itself (+ 0.24009) and the rest was due to indirect effect via leaf area (+ 0.15374), via number of tillers (+ 0.08707) and via number of leaves (+ 0.03365). Thus the overall association of plant height with green weight of stem was mainly due to its direct effect and indirect effect through leaf area only.

2. Green weight of stem v/s number of tillers

The manifestation of the simple correlation (+ 0.83544) between green weight of stem and number of tillers were the direct effect of number of tillers on green weight of stem (+ 0.49802) followed by the indirect effect via number of leaves (+ 0.34144). Practically there was no effect via plant height (+ 0.04233) and via leaf area (- 0.04635) since the more or less same positive and negative values mutually neutrilized their effects.

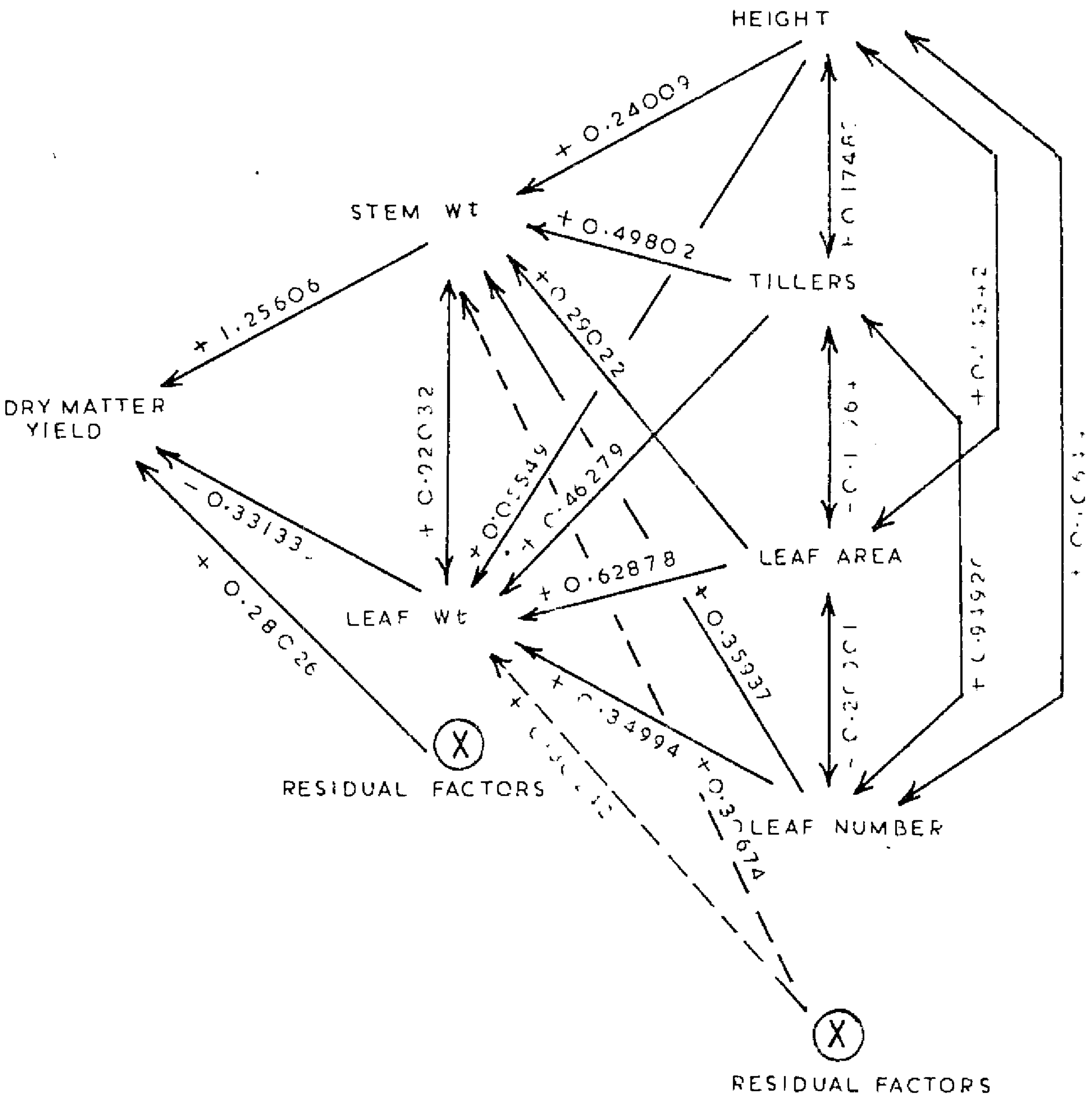
TABLE 9

The direct and indirect relationship between variables of second order components of total dry matter yield (green weight of stem and its components)

Variables			Path coefficient
1. Green weight of stem v/s plant height	r	=	+ 0.52455
Direct effect	$P_{1.3}$	=	+ 0.24009
Indirect effect via no. of tillers	$P_{1.4}r_{3.4}$	=	+ 0.08707
Indirect effect via leaf area	$P_{1.5}r_{3.5}$	=	+ 0.15874
Indirect effect via no. of leaves	$P_{1.6}r_{3.6}$	=	+ 0.03865
Total		=	+ 0.52455
2. Green weight of stem v/s no. of tillers	r	=	+ 0.83544
Direct effect	$P_{1.4}$	=	+ 0.49802
Indirect effect via plant height	$P_{1.3}r_{3.4}$	=	+ 0.04233
Indirect effect via leaf area	$P_{1.5}r_{4.5}$	=	- 0.04635
Indirect effect via no. of leaves	$P_{1.6}r_{4.6}$	=	+ 0.34144
Total		=	+ 0.83544
3. Green weight of stem v/s leaf area	r	=	+ 0.26723
Direct effect	$P_{1.5}$	=	+ 0.29022
Indirect effect via no. of tillers	$P_{1.4}r_{4.5}$	=	- 0.07950
Indirect effect via plant height	$P_{1.3}r_{3.5}$	=	+ 0.13158
Indirect effect via no. of leaves	$P_{1.6}r_{5.6}$	=	- 0.07517
Total		=	+ 0.26723
4. Greent weight of stem v/s no. of leaves	r	=	+ 0.79679
Direct effect	$P_{1.6}$	=	+ 0.35937
Indirect effect via leaf area	$P_{1.5}r_{5.6}$	=	- 0.06065
Indirect effect via no. of tillers	$P_{1.4}r_{4.6}$	=	+ 0.47271
Indirect effect via plant height	$P_{1.3}r_{3.6}$	=	+ 0.02536
Total		=	+ 0.79679
5. Residual factors	$P_{1.x}$	=	+ 0.30674

PLATE № V

DIAGRAMMATIC REPRESENTATION OF PATH COEFFICIENTS



3. <u>Green weight of stem v/s leaf area</u>

When compared to the other components leaf area had low correlation coefficient (+ 0.26723), but its indirect effect was slightly higher (+ 0.29022). The indirect effect via plant height was + 0.13158. The indirect effect via number of tillers (- 0.07950) and via number of leaves (- 0.07517) were negative and negligible. The net effect of this system was, therefore, primarily due to the direct effect.

4. <u>Green weight of stem v/s number of leaves</u>

The number of leaves exhibited comparatively high correlation with green weight of stem (+ 0.79679). It resulted almost entirely from the direct effect of the character itself (+ 0.35937) as well as due to indirect effect via number of tillers (+ 0.47271). The other effects, via plant height (+ 0.02536) and via leaf area (- 0.06065) were very small and negligible.

(b) <u>Green weight of leaves and its components</u>

1. <u>Green weight of leaves v/s plant height</u>

The simple correlation between plant height and green weight of leaves (+ 0.5 1515) was mainly due to the indirect effect through leaf area (+ 0.34148) than the direct effect of the trait itself (+ 0.05549). The indirect effect through number of tillers (+ 0.08094) and through number of leaves were (+ 0.03724) positive and negligible in magnitude.

2. Green weight of leaves v/s number of tillers

The highest correlation coefficient exhibited among the characters of this group obtained between green weight of leaves and number of tillers (+ 0.70409) comprised largely of the direct effect of number of tillers itself (+ 0.46279) supplemented with the indirect effect via nuber of leaves (+ 0.33207), leaf area (- 0.10037) and indirect effect through plant height (+ 0.00960) were very small.

3. Green weight of leaves v/s leaf area

The direct effect of leaf area was + 0.62878, which only in part was manifested by the simple correlation coefficient (+ 0.51224) as the part of this was nullified by the negative indirect effect through number of tillers (- 0.07387) and through number of leaves (- 0.07313). Negligible positive indirect effect via plant height was + 0.03046.

4. Green weight of leaves v/s number of leaves

The correlation coefficient of these two traits (+ 0.66597) was due to the direct effect (+ 0.34994) and the indirect effect via number of tillers (+ 0.43929). The indirect effect through leaf area (- 0.13122) was negative and through plant height (+ 0.00795) was very low and hence did not carry any appreciable weight towards the contribution of that trait to the manifestation of the comparatively high correlation value.

The direct and indirect effects of plant height, number of tillers, leaf area and number of leaves are compiled in table 10 and the diagrammatic representation of path coefficients are given in plate V.

The coefficient of determination is another index which is the fraction of complete determination of one variable for which the cause of another variable is directly responsible in a given system of related variables i.e., the sum of coefficient of all such causes must be equal to unity. Due to the complexity of the characters, correlation studies as well as path coefficient analysis may be misleading in finding out the major components, unless the volume of the effect is not determined. The residual factor analysis gives the magnitude of the effect of the causes under study and the effect of external factors, which could not be taken in to consideration.

The residual factor analysis in the three sets, viz. first order components and the two sets of second order

TABLE 10

The direct and indirect relationships between variables of the second order components of total dry matter yield (green weight of leaves and and its components .

Variables			Path coefficient
1. Green weight of leaves v/s plant height	r	=	+ 0.51515
Direct effect	$P_{2.3}$	=	+ 0.05549
Indirect effect via no. of tillers	$P_{2.4}r_{3.4}$	=	+ 0.08094
Indirect effect via leaf area	$P_{2.5}r_{3.5}$	=	+ 0.34148
Indirect effect via no. of leaves	$P_{2.6}r_{3.6}$	=	+ 0.03724
Total		=	+ 0.51515
2. Green weight of leaves v/s no.of tillers	r	=	+ 0.70409
Direct effect	$P_{2.4}$	=	+ 0.46279
Indirect effect via plant height	$P_{2.3}r_{3.4}$	=	+ 0.00960
Indirect effect via leaf area	$P_{2.5}r_{4.5}$	=	- 0.10037
Indirect effect via no. of leaves	$P_{2.6}r_{4.6}$	=	+ 0.33207
Total		=	+ 0.70409
3. Green weight of leaves v/s leaf area	r	=	+ 0.51224
Direct effect	$P_{2.5}$	=	+ 0.62878
Indirect effect via no. of tillers	$P_{2.4}r_{4.5}$	=	- 0.07387
Indirect effect via plant height	$P_{2.3}r_{3.5}$	=	+ 0.03046
Indirect effect via no. of leaves	$P_{2.6}r_{5.6}$	=	- 0.07313
Total		=	+ 0.51224
4. Green weight of leaves v/s no. of leaves	r	=	+ 0.66597
Direct effect	$P_{2.6}$	=	+ 0.34994
Indirect effect via leaf area	$P_{2.5}r_{5.6}$	=	- 0.13122
Indirect effect via no. of tillers	$P_{2.4}r_{4.6}$	=	+ 0.43929
Indirect effect via plant height	$P_{2.3}r_{3.6}$	=	+ 0.00795
Total		=	+ 0.66597
5. Residual factors	$P_{2.x}$	=	+ 0.30242

components, exhibited the values + 0.28026, + 0.30674 and + 0.30242 respectively, revealing that more effects were due to the characters selected under studies than those which could not selected for the analysis.

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DISCUSSION

The success of breeder in improving a material depends on the existence and exploitation of genetic variability to the fullest extent. The observable variability among individuals, thus, gets the prime importance. The break up of the phenotypic variations gives the environmental variance and genotypic variance. The estimation of genetic variability alone is insufficient to give complete information about the magnitude of improvement that can be achieved. Therefore, the estimation of genetic parametree like heritability, genetic advance and genetic gain are indespensable.

Very high genotypic and phenotypic variance was observed in total green yield followed by green weight of stem, number of leavee, leaf area, green weight of leaves, number of tillers and plant height. Similar findings were also reported by Moore and Edwarde (1969) for heading date and height in oats.

Heritability

Heritability, being the potentiality of an individual to inherit a trait in to its offsprings, gets the prime importance. Heritability indicate the stability of genetic actions which enables to choose a proper breeding programme. In the present studies high heritability values were obtained for almost all characters except per cent crude protein content.

Petr and Frey (1966) observed high heritability values in plant height, panicle length, heading date etc. Bhagmal <u>et al</u>.(1970) found high heritability values for days to maturity, tiller number, number of leaves, leaf length and breadth and stem/leaf ratio. Muehlbauer <u>et al</u>. (1971) estimated heritability of plant height and straw strength and found high values.

This imply that selection in these characters based on the phenotypes would be meaningful.

<u>Expected genetic advance</u>

At certain level of selection pressure, the shift of a population towards the superior side of genetic action is meant by genetic advance. Very high genetic advance was exhibited by total green yield and green weight of stem, while green weight of the leaves, number of leaves, leaf area, plant height, days to emergence of flag leaf, days to maturity and dry matter yield had moderate values (at 5 per cent level of selection pressure) which indicated that genetic variation was mainly due to additive gene action (Panse,1957).

Genetic gain

The expected percentage of genetic advance based on mean of character was highest for green weight of leaves followed by leaf area, total green yield, number of leaves, green weight of stem and number of tillers. Phul et al. (1972) also reported high genetic gain in forage yield and number of tillers.

Genetic coefficient of variation

The magnitude of the genetic variation existed in the charactera, selected for studies, was estimated to get the standardized variation in these characters. Moderately high genetic coefficient of variation was observed in green weight of leaves, leaf area, total green yield, green weight of stem, number of leaves and number of tillers. Phul et al. (1972) also reported similar type of results for forage yield and tiller number.

The number of leaves, leaf area, number of tillers, plant height and green weight of stem exhibited high values of heritability, expected genetic advance, genetic gain and genetic coefficient of variation and hence significant improvement can be brought about by exploiting these characters through selection.

Correlation of characters with dry matter yield

To measure the extend of dependance of the components of dry matter yield as well as their mutual association, the analysis of correlation coefficient is the most efficient method. The phenotypic correlation in almost all characters, were slightly lower than the genotypic correlation coefficients, which proved the least environmental influence.

In the present study fourteen plant characters were analysed to find out their relationship with dry matter yield. Except the per cent crude protein, all characters exhibited high significant correlation with dry matter yield. Dent (1957) also observed the non-significant relationship between protein content and straw yield in cultivated oats. Suthman and Marten (1972) also measured variation for quality traits and found that forage yield was correlated with plant height and heading date.

The correlation of dry matter yield with stem/leaf ratio as well as with per cent dry weight showed negative relationship. The per cent dry weight also had negative relationship with dry matter yield.

<u>Relationship between first order components</u>

Green weight of stem and green weight of leaves had high positive correlation with dry matter yield as well as between themselves indicating that improvement, if, brought about in these two characters would positively lead to high dry matter yield.

Relationship between second order components

As the characters of first order components are notindependent, being influenced by other morphological characters, the nature of association between them were also worked out.

The correlation studies of the morphological characters like, plant height, leaf area, number of leaves and number of tillers with that of green weight of stem and green weight of leaves indicated that the number of leaves had less influence on the green weight of leaves, whereas it had high significant relationship with green weight of stems. Other three characters had very high correlation values.

Since all these characters were taken as second order components the correlation between these in all possible combinations were also worked out. The result showed that number of tillers and number of leaves had high relationship followed by the relationship of plant height and leaf area. Plant height and number of tillers were independent, since they had non-significant relationship. Solanki _et al_. (1973) also reported a positive association of green yield in oats with plant height and tiller number and leaf breadth.

In the present studies, all the four morphological characters exhibited their importance in influencing the green weight of stem and leaves and their mutual relationship. Hence further improvement can be expected by imposing more emphasis on these characters, while framing breeding programme.

Path coefficient analysis

The correlation coefficient gives only a vague idea of the relationship between dry matter yield and its causes. The path analysis suggested by Wright (1921), discussed by Li (1955) and used by Durate and Adams (1972) for the analysis of first and second order components untangle the direct and indirect contributions of the various factors in building up of the main character.

1. First order components

The green weight of stem and leaves, being immediate causes of dry matter yield, were analysed for their direct and indirect effects as the first order components. The green weight of the stem had the higher correlation coefficient (+ 0.95113) than the green weight of leaves (+ 0.82464). The partitioning of the correlation indicated a high positive direct effect (+ 1.25606) of green weight of stem. On the contrary the direct relationship of the green weight of the leaves was negative (- 0.33133), but the indirect effect via green weight of stem was very high and positive (+ 1.15597).

Phul *et al.* (1972) in the path analysis of the components of fodder sorghum found major roles of stem girth and length and breadth of leaves.

The present analysis clearly indicate that the role of green weight of leaves in increasing dry matter yield was not due to its direct effect but was due to its indirect effect through the green weight of stem. As the photosynthates are translocated from leaves to stem, where it accumulates to increase the dry matter yield and hence the influence of green weight of leaves showing the indirect effect via green weight of stem is justifiable.

2. Second order components

Among the second order components, only the number of tillers, leaf area and number of leaves had high direct effects on green weight of stem as well as on green weight of leaves. The rest of the simple association of the number of tillers and number of leaves with green weight of stem as well as with green weight of leaves were also mainly due to their indirect effects through number of leaves and number of tillers respectively. The high positive association of plant height and green weight of leaves was also mainly due to its indirect effect through leaf area.

The residual factor analysis for the unknown causes disclosed comparatively low value to conclude that the impact of the external factors were negligible.

Dewey and Lu (1959) also reported that the plant size had significant positive effect on fodder yield in wheatgrass. Koeing and Walter (1966) obtained significantly high relationship of leaf number, and leaf area towards green yield in sorghum. Naphade (1972) found major role of the number of leaves per plant towards the contribution of fodder yield in sorghum. Dahiya (1973) observed positive direct effect of plant height, stem thickness and dry matter yield on green fodder yield in sorghum; but the direct effect of number of leaves and leaf area were negative. Patel <u>et al</u>. (1973) found that the direct effect of plant height, leaf area and length of internode were the major causes of fodder yield in sorghum. Sharma <u>et al</u>. (1973) reported high direct effect of number of tillers on fodder yield in barley. Solanki <u>et al</u>. (1973) obtained maximum direct effect of height on green yield of oats.

Therefore, number of tillers, leaf area and number of leaves are to be considered as major components for the increase of green weight of stem and leaves, which are the immediate causes for the accumulation of dry matter in oats. In addition, all these characters showed high heritability, expected genetic advance, genetic gain and genetic coefficient of variation and hence main emphasis has to be excerted for improving these three characters which would not only improve the green weight of stem and green weight of leaves but ultimately the dry matter yield would be enhanced.

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SUMMARY

Present investigations were undertaken to evaluate the thirty two diversed varieties of oats for their variability, heritability, genetic advance, genetic gain and genetic coefficient of variation. Path coefficient analysis of component characters of fodder yield was also done to partition their effects into direct and indirect influences.

Experiment was conducted at the farms of Rajasthan College of Agriculture, Udaipur during the rabi season of 1975-76. The salient findings are summarized below.

High heritability values were obtained in characters like days to flag leaf emergence (99.696), days to maturity (99.681), stem leaf ratio (98.686), number of leaves (96.028), leaf anglo (95.009), number of tillers (95.285), leaf area (94.713), plant height (92.065), green weight of stem (90.670), green weight of leaves (91.158), total dry matter yield (91.506) and total green yield (90.742).

High values of expected genetic advance were obtained in total green weight (88.561), green weight of stem (62.013), green weight of leaves (36.769), number of

leaves (30.176), leaf area (29.715), plant height (25.439), days to flag leaf emergence (20.640), days to maturity (20.326), and total dry matter yield (18.960), which indicate the genetic variation was due to additive gene action.

The maximum genetic gain was observed in green weight of leaves (78.237) followed by leaf area (56.325), total green weight (54.526), number of leaves (53.833), green weight of stem (53.550), number of tillers(50.792), total dry matter yield (46.543), stem/leaf ratio(38.749), per cent ash content (26.712) and plant height (20.265).

The genetic coefficient of variation was also high in the following characters. Green weight of leaves (33.688), leaf area (28.092), green weight of stem(27.288), total green weight (27.770), number of leaves (26.672), number of tillers (25.364) and stem/leaf ratio (18.950).

The correlation between dry matter yield and all other fourteen characters were worked out to get the extend of relationship. Except per cent of crude protein (- 0.10192) and leaf angle (+ 0.19921) exhibited high significant correlations. Stem/leaf ratio and per cent dry weight had negative relationship with dry matter yield.

The characters selected on the basis of the parametres of genetic variance like heritability, expected genetic advance etc. as well as high significant correlatio were analysed for correlation coefficient in all combinatio

According to the magnitude of the degree of relationship the characters were grouped into first order components and second order components for further analysis of direct and indirect causes.

Green weight of stem and green weight of leaves, being the immediate causes for the accumulation of dry matter, were taken as first order components.

The direct and indirect effects revealed that green weight of stem had much influence on the dry matter accumulation since its direct effect (+ 1.25606) and the indirect effect of weight of leaves via weight of stem (+ 1.15597) were very high, whereas the direct effect of weight of leaves and indirect effect of weight of stem via leaves were negative and low.

The plant height, number of tillers, leaf area and number of leaves had direct relationship on green weight of stem and leaves and hence were selected as secon order components. Its possible direct and indirect effect on both the first order components revealed that le had more influence (direct effects on green weight was + 0.29022 and on green weight of leaver than the other three characters, because it was higher than that of the correlation co leaves (30.176), leaf area (29.715), plant height (25.438), days to flag leaf emergence (20.640), days to maturity (20.326), and total dry matter yield (18.960), which indicate the genetic variation was due to additive gene action.

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The plant height, number of tillers, leaf area and number of leaves had direct relationship on green weight of stem and leaves and hence were selected as second order components. Its possible direct and indirect effects on both the first order components revealed that leaf area had more influence (direct effects on green weight of stem was + 0.29022 and on green weight of leaves was +0.62873) than the other three characters, because its direct effect was higher than that of the correlation coefficient values.

Number of tillers and number of leaves also had high influence on increase of green weight of stem and leaves, but plant height had comparatively low direct effect as the part of its simple association with the other characters.

The conclusions based on the analysis were good enough to decide that expectations on higher yield could be fulfilled by concentrating our selection efforts mainly on these three characters i.e., leaf area, number of tillers and number of leaves.

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Appendix I

Analysis of variance for days to flag leaf emergence

Source of variation	d.f.	SS	MSS	F
Replication	3	11.00	3.67	3.0474*
Treatment	31	12531.00	404.23	335.6555**
Error	93	112.00	1.204	
Total	127	12654.00		

* Significant at 5 per cent level.
** Significant at 1 per cent level.

C.D. at 5% = 1.544

Appendix II

Analysis of variance for days to maturity

Source of variation	d.f.	SS	MSS	F
Replication	3	2.00	0.67	0.5372
Treatment	31	12152.00	392.00	314.2788**
Error	93	116.00	1.247	
Total	127	12270.00		

** Significant at 1 per cent level.

C.D. at 5% = 1.572

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Appendix III

Analysis of variance for plant height

Source of variation	d.f.	SS	MSS	F
Replication	3	374.00	124.67	3.0722*
Treatment	31	15846.48	511.18	12.5968**
Error	93	3773.60	40.58	
Total	127	19994.08		

* Significant at 5 per cent level.
** Significant at 1 per cent level.

C.D. at 5% = 8.957

Appendix IV

Analysis of variance for number of tillers

Source of variation	d.f.	SS	MSS	F
Replication	3	44.78	14.93	8.7309**
Treatment	31	1130.36	36.46	21.3216**
Error	93	158.74	1.71	
Total	127	1333.88		

** Significant at 1 per cent level.

C.D. at 5% = 1.803

Appendix V

Analysis of variance for number of leaves

Source of variation	d.f.	SS	MSS	F
Replication	3	134.61	51.54	1.3922
Treatment	31	28879.12	931.58	25.1642**
Error	93	3443.09	37.02	
Total	127	32476.82		

** Significant at 1 per cent level.

C.D. at 5% = 8.536

Appendix VI

Analysis of variance for leaf angle

Source of variation	d.f.	SS	MSS	F
Replication	3	28.79	9.60	4.4859**
Treatment	31	1317.53	42.50	19.8598**
Error	93	199.01	2.14	
Total	127	1545.33		

** Significant at 1 per cent level.

C.D. at 5% = 2.049

Appendix VII

Analysis of variance for leaf area

Source of variation	d.f.	SS	MSS	F
Replication	3	262.10	87.36	1.1770
Treatment	31	28756.77	927.63	25.9718**
Error	93	6902.85	74.22	
Total	127	35921.70		

** Significant at 1 per cont level.

C.D. at 5% = 12.1002

Appendix VIII

Analysis of variance for green weight of stem

Source of variation	d.f.	SS	MSS	F
Replication	3	5340.97	1780.32	4.3276**
Treatment	31	136674.7[illegible]	4408.86	10.7175**
Error	93	38257.78	411.37	
Total	127	170273.49		

** Significant at 1 per cent level.

C.D. at 5% = 28.473

Appendix IX

Analysis of variance for green weight of leaves

Source of variation	d.f.	SS	MSS	F
Replication	3	305.17	101.72	1.0414
Treatment	31	33911.72	1093.93	11.1773**
Error	93	9083.68	97.67	
Total	127	43300.57		

** Significant at 1 per cent level

C.D. at 5% = 13.8799

Appendix X

Analysis of variance for total green yield

Source of variation	d.f.	SS	MSS	F
Replication	3	2058.31	686.10	0.8256
Treatment	31	278283.11	8976.87	10.8021**
Error	93	77285.77	831.03	
Total	127	357627.19		

** Significant at 1 per cent level.

C.D. at 5% = 40.4773

Appendix XI

Analysis of variance for stem weight/leaf weight ratio

Source of variation	d.f.	SS	MSS	F
Replication	3	1.4117	0.4706	3.6765*
Treatment	31	30.2812	0.9768	7.6312**
Error	93	11.9349	0.0128	
Total	127	43.6278		

* Significant at 5 per cent level
** Significant at 1 per cent level.

C.D. at 5% = 0.2049

Appendix XII

Analysis of variance for total dry matter weight

Source of variation	d.f.	SS	MSS	F
Replication	3	96.43	32.14	0.9343
Treatment	31	12555.47	405.01	11.7735**
Error	93	3199.32	34.40	
Total	127	15851.22		

** Significant at 1 per cent level

C.D. at 5% = 8.2330

Appendix XIII

Analysis of variance of per cent dry weight

Source of variation	d.f.	SS	MSS	F
Replication	3	11.50	3.83	0.9075
Treatments	31	1168.02	37.68	8.9289**
Error	93	392.69	4.22	
Total	127	1572.21		

** Significant at 1 per cent level

C.D. at 5% = 2.8773

Appendix XIV

Analysis of variance for per cent crude protein

Source of variation	d.f.	SS	MSS	F
Replication	3	6.4799	2.1600	0.7866
Treatment	31	275.8811	8,8994	3.2412**
Error	93	255.3536	2.7457	
Total	127	537.7146		

** Significant at 1 per cent level

C.D. at 5% = 2.3256

Appendix XV

Analysis of variance for per cent ash content

Source of variation	d.f.	SS	MSS	F
Replication	3	3.666	1.222	0.4559
Treatment	31	362.820	11.704	4.3672**
Error	93	249.304	2.680	
Total	127	615.790		

** Significant at 1 per cent level

C.D. at 5% =

Appendix XVI

Genotypic and phenotypic covariances between dry matter yield and the other characters

Characters	Dry matter yield	
	Genotypic	Phenotypic
1. Days to flag leaf emergence	+ 27.4413	+ 27.5011
2. Days to maturity	+ 32.1516	+ 32.3030
3. Plant height	+ 62.5001	+ 63.8842
4. Number of tillers	+ 22.5807	+ 22.8831
5. Number of leaves	+101.2145	+ 103.3017
6. Leaf angle	+ 6.1014	+ 5.7422
7. Leaf area	+ 44.4341	+ 47.0582
8. Green weight of stem	+289.4347	+ 311.7175
9. Green weight of leaves	+125.4771	+ 139.2864
10. Total green yield	+407.2814	+ 435.0627
11. Stem/leaf ratio	- 1.2723	- 1.1717
12. Per cent dry weight	- 7.1315	- 8.3536
13. Per cent crude protein	- 1.2173	- 0.9664
14. Per cent ash content	+ 4.9073	+ 4.0134

Appendix XVII

Genotypic and phenotypic covariances in all possible combinations of the characters selected for path coefficient analysis

		Dry matter yield	Green weight of stem	Green weight of leaves	Plant height	Number of tillers	Leaf area	Number of leaves
Dry matter yield	(G)	x	+ 289.4347	+ 125.4771	+ 62.5001	+ 22.5807	+ 44.4341	+101.2145
	(P)		+ 311.7175	+ 139.2864	+ 63.8842	+ 22.8831	+ 47.0582	+103.3017
Green weight of stem	(G)		x	+ 459.5028	+179.6829	+ 77.8841	+125.1527	+376.4216
	(P)			+ 496.7846	+ 187.2844	+ 78.6627	+138.9213	+384.6139
Green weight of leaves	(G)			x	+ 83.2315	+ 32.8185	+119.9465	+157.3102
	(P)				+ 87.9046	+ 32.3894	+126.6019	+163.7234
Plant height	(G)				x	+ 5.5982	+ 87.3055	+ 17.2573
	(P)					+ 5.3228	+ 88.1794	+ 17.7642
No. of tillers	(G)					x	- 6.9795	+ 41.8667
	(P)						- 6.9679	+ 42.6295
Leaf area	(G)						x	- 46.3153
	(P)							- 44.8047
No. of leaves	(G)							x
	(P)							