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PATH ANALYSIS IN OPIUM POPPY (*PAPAVER SOMNIFERUM* L.)

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ABSTRACT

The genotypic coefficient of variation and heritability values in twenty strains of opium poppy were low for latex yield, morphine content and seed yield. These values were high for capsule breadth and capsule number. The partitioning of genotypic association of latex yield revealed maximum direct contribution from morphine percentage (negative), capsule breadth and leaf number. Direct effects of sizeable negative magnitude were also recorded for plant height, capsule number and seed yield. A plant type with few capsules, which are broad in middle, dwarf stature, large leaf (the four upper most leaves) is suggested for increased latex yield.

Key words: Genotypic correlation, genotypic variation, heritability, latex yield, morphine, opium poppy, path analysis.

Opium poppy is a medicinal plant cultivated primarily for its latex rich in morphine (an alkaloid). It is cultivated in Madhya Pradesh, Rajasthan and Uttar Pradesh under the control of Narcotics Department by licenced growers and is a valuable source of foreign exchange. Only limited studies on variability in this crop have been done in the past [1, 2]. The present investigation is based on altogether different set of characters and genotypes. It extends and elaborates the information published in the earlier reports.

MATERIALS AND METHODS

The experimental material comprised twenty strains developed under the All India Coordinated Project on Medicinal and Aromatic Plants. The material was grown at the Rajasthan College of Agriculture, Udaipur in RBD with four replications. Observations were recorded on ten 30 x 30 cm spaced plants in each plot. Leaf area of four upper most leaves was recorded at flowering. The genotypic coefficient of variation [3], heritability in broad sense [4], correlations [5], direct and indirect effects [6] were calculated as per standard methods.

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RESULTS AND DISCUSSION

The genotypic coefficient of variation and heritability values (Table 1) were low for latex yield (6.2, 28.6), morphine content (13.8, 32.7) and seed yield (16.7, 32.1). The experimental material comprised improved strains which are either advanced selections or varieties. These have already undergone considerable selections and are maintained as small populations therefore show low heritability. These three characters are associated with reproductive fitness and manifest low heritability as in most other crops. Therefore, improvement through correlated characters could be more effective. Selection for capsule breadth (44.5, 79.4) and capsule number (48.2, 67.6) would be effective and satisfactory for practical purposes.

Table 1. Genotypic coefficient of variation and heritability of nine characters in opium poppy

Character	Genotypic coefficient of variation	Heritability
Plant height	22.9	61.3
Days to flowering	26.2	59.0
Leaf number	20.8	63.1
Leaf area	23.7	59.8
Capsule number	48.2	67.6
Capsule breadth	44.5	79.4
Seed yield per plant	16.7	32.1
Morphine content	13.8	32.7
Latex yield per plant	6.2	28.6

The genotypic correlation coefficients (Table 2) of latex yield were positive with days to flowering, capsule breadth, leaf area of the four upper most leaves at flowering, seed yield and plant height, but negative with morphine content, capsule number and leaf number. The partitioning of total genotypic association between latex yield and other characters (Table 2) revealed that the maximum direct but negative (–0.52) contribution was observed

Table 2. Genotypic correlation coefficients among nine characters and direct effects of eight characters influencing latex yield in opium poppy

Characters	Days to flowering	Leaf number	Leaf area	Capsule number	Capsule breadth	Seed yield	Morphine content	Latex yield	Direct effect on latex yield
Plant height	0.43	0.23	0.65	0.62	0.76	0.32	0.09	0.13	–0.28
Days of flowering		0.63	0.57	0.74	0.64	0.60	0.13	0.67	0.08
Leaf number			0.16	0.32	0.21	0.45	0.38	–0.17	0.34
Leaf area				0.52	0.78	0.79	–0.04	0.39	0.15
Capsule number					–0.42	0.49	–0.24	–0.34	–0.27
Capsule breadth						0.64	–0.25	0.53	0.40
Seed yield							0.26	0.24	–0.27
Morphine content								–0.38	–0.52

for morphine content. Latex yield received maximum direct contribution from capsule breadth (0.40) and leaf numbers (0.34). The genotypic correlation coefficient between morphine content and latex yield is almost equal to its direct effect, and both are negative, which explains true inverse relationship between these characters. However, the less than moderate level of negative association necessitates large scale screening of recombinants for breaking this association.

The situation of negative correlation between latex yield and morphine content resembles widespread negative correlations between grain yield and grain protein content in barley, maize, oat, sorghum and wheat [7]. Protein concentration in corn grain is affected by genetic constitution [8] and to small extent by soil nitrogen and other environmental conditions [9]. A weak negative correlation exists between grain yield and protein content, and a strong negative correlation between protein content and lysine percentage in protein in pearl millet [10]. Since nitrogen availability next to water is frequently the limiting environment factor influencing yield of crop plants, the negative relationship between yield and protein content is a reality in production systems [11]. Both grain yield and protein content can be increased simultaneously up to a certain level, with an adequate nitrogen supply to the plants and its efficient translocation to developing grain [12].

Evaluation of fifty different collections from Kota district of Rajasthan revealed that only four genotypes high in latex yield were also high in morphine content [13].

Effect of plant population and nitrogen fertilization on yield and yield attributes was reported in opium poppy varieties [14]. Morphine content significantly differed for varieties. Morphine content did not increase significantly with increase in spacing (30 x 10, 30 x 15, 45 x 10, 45 x 15 cm^2). or nitrogen level (30, 60, 90 kg/ha) up to optimum nitrogen level of 90 kg/ha. With decrease in plant population per unit area from 333333 to 148148 plants per hectare, latex yields per plant were increased. The decrease in plant population was compensated by increase in per plant latex yield mainly by number of fully developed capsules. Increase in nitrogen levels from 30 to 90 kg/ha resulted with increase in latex yield from 56.69 to 67.40 kg/ha at 70^o consistency due to increased number of effective capsules per plant (1.25–3.36) and total capsule volume (26.4–49.3 ml) per plant. Therefore, morphine yield per hectare was ultimately increased with increase in nitrogen fertilization [14].

Owing to such a formidable negative correlation, a reduction in morphine content of modern high latex yielding opium poppy varieties has occurred mainly due to selection favouring latex yield alone. A concurrent choice of both latex yield and morphine content will largely mitigate the situation. Variation for both the traits co-exist in opium poppy germplasm. Induction of mutant alleles responsible for high morphine content in latex could

further enlarge the spectrum of genetic variation. With such a range of variability, making interfamily selection for high latex yield, followed by intrafamily selection for high morphine content from selected productive families, would thus offset the ill-effects of negative correlation between latex yield and morphine content. The negative association between latex yield and morphine content per unit of latex yield can also be modified favourably through recurrent selection, which could increase morphine content differentially in different varieties of opium poppy.

The genotypic correlation coefficient between capsule breadth and latex yield is almost equal to its direct effect. Therefore, capsule breadth can be effectively used as a direct selection criteria for latex yield.

Correlation between leaf number and latex yield is mildly negative (r = –0.17) but the direct effect is positive (0.34). In such case, a restricted simultaneous selection model can be followed. Restrictions should be imposed to nullify the undesirable indirect effect via capsule number (–0.30) and seed yield (–0.26) in order to make use of the direct effect.

The genotypic association (–0.34) and direct effects (–0.27) of capsule number are negative and less than moderate, suggesting selection of plants with one or two capsules per plant for increased latex yields.

The indirect effects of leaf area via capsule breadth (0.30) are almost equal to the correlation coefficient (0.39) and seems to be the cause of association. The indirect effect of days to flowering via capsule number (0.61), morphine content (0.15), leaf area (0.13) and capsule breadth (0.10) seems to be the cause of correlation.

The direct effect of plant height (–0.28) on latex yield is negative, therefore selection of dwarf plants should favour high latex yield.

Therefore, selection of a plant type possessing few capsules, which are broad in middle, dwarf plant, and large area of the four upper most leaves at flowering should be made for increased latex yield.

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